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Technical Report

No. 13236

ELECTRIC DRIVE STUDY

VOLUME 2 OF 2

CONTRACT NUMBER DAAE07-84-C-R017

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APPENDIX A

TECHNOLOGY SURVEY SUMMARY

Appendix A Technology Survey Summary

A.1 Technology Report

As required by contract DAAE07-84-C-R017, a comprehensive technology survey report was prepared between February and August 1984. This report details the approach and results of a survey of motors, solid-state controls, alternator/generators, and servo components which were potential candidates for the advanced electric drive study. In addition, solid-state components and various materials such as advanced magnetics were included in the survey. The survey report was approved in January 1985.

A.2 Survey Update

The motor tree at Figure A.2-1 formed the basis for the motor survey. Results of the survey effort for motor selection is shown in Figure A.2-2. This selection process was the result of an extensive matrix/tradeoff analysis and was initially used in early concept development. As the concepts were refined, performance vehicle factors became an influence in the motor component selection. The result of the influence was the selection of the Homopolar motor for the DC system and the high frequency induction motor for the AC system. The selection of these motors for the Configuration I analysis dictated the additional system components such as the motor power conditioners/controllers and the alternator/generators.

Figure A.2-3 compares the selected motors with respect to operational and characteristic attributes. The hybrid permanent magnet (PM) "brushless" motor is included in the comparison to indicate the effect of relative complexity introduced by the total PM motor/power conditioner system. In this comparison, the DC and AC motors operate independent of an external power conditioner.

It is apparent for this update comparison that no clear "best" motor component selection is possible since each different type has certain advantages not shared by the other.

Motor power controllers/conditioners are compared in Figure A.2-4. In this comparison, the DC system appears to have some advantage due to the inherent gain of the DC motor and thus the lack of any power semiconductors. The power controllers/conditioners for the AC and hybrid motors are all DC to AC inverter systems and are designed around large power semiconductors.

A comparison of selected alternator and generator technologies is shown in figure A.2-5. In this comparison, the AC alternator candidate is a standard aircraft design with an operating frequency of 400 Hz.

The present status of candidate power semiconductors is shown in Figure A.2-6. As expected, the semiconductor industry continues

to work on improvements to increase the voltage and current capability and reduce the turn-on/turn-off time. No significant technology break-through's are presently foreseen in this area which would produce a radical improvement for use in high power drive systems.

It is unfortunate that the majority of high power semiconductor research is being done outside the United States.

Figure A.2-7 documents the trend in magnetic materials used in permanent magnet motors. With the introduction of Neodymium/Iron/Boron, an alternative is not available to replace, Smarium-Cobalt magnets for high energy density applications. Neodymium/Iron/Boron will continue to be improved and should be seen in products within the next 3 to 5 years. The use of this new material should yield a significant weight reduction and associated cost reduction in motors and generators.

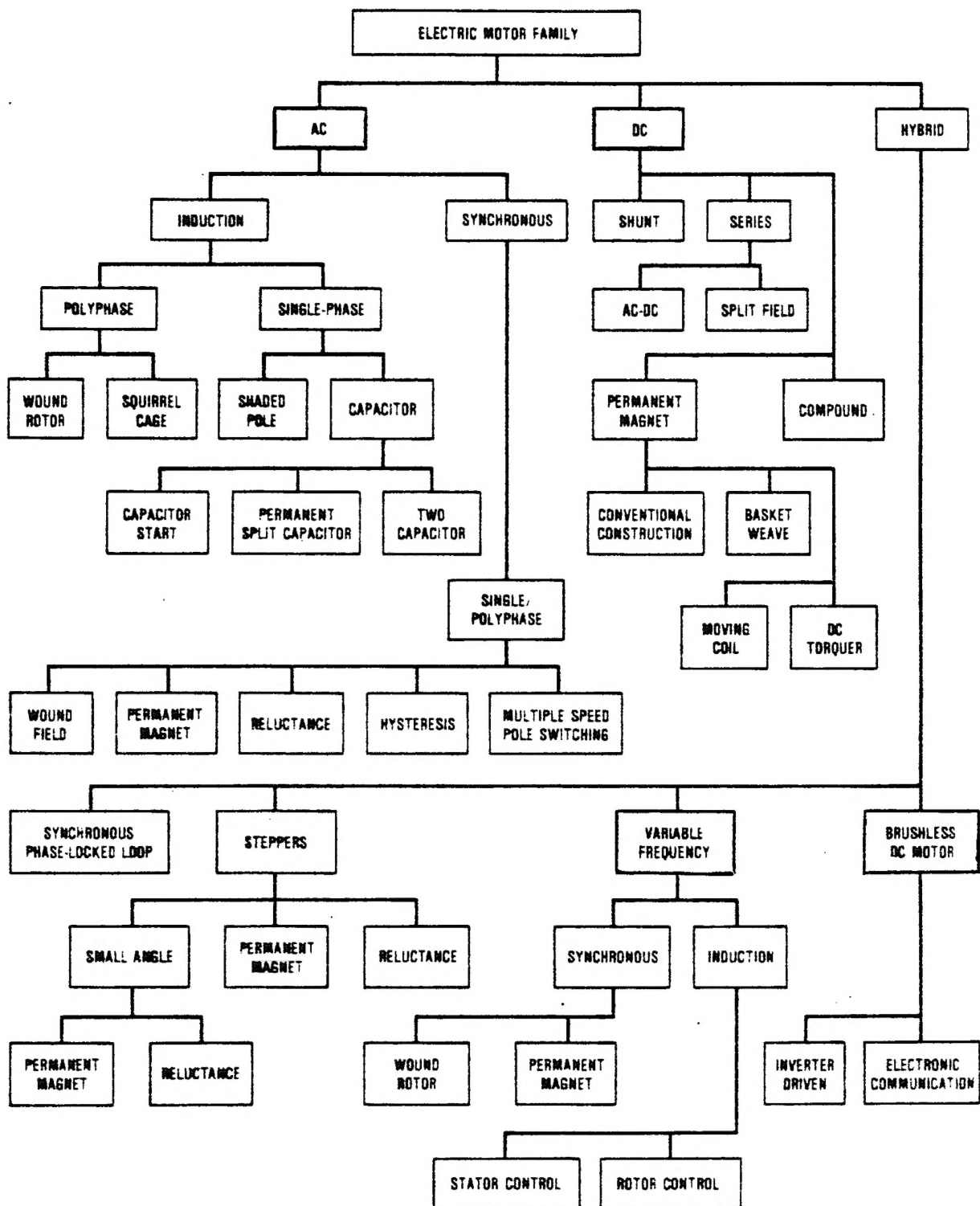


Figure A.2-1 Electric Motor Technology Tree

Motor Technology Screen

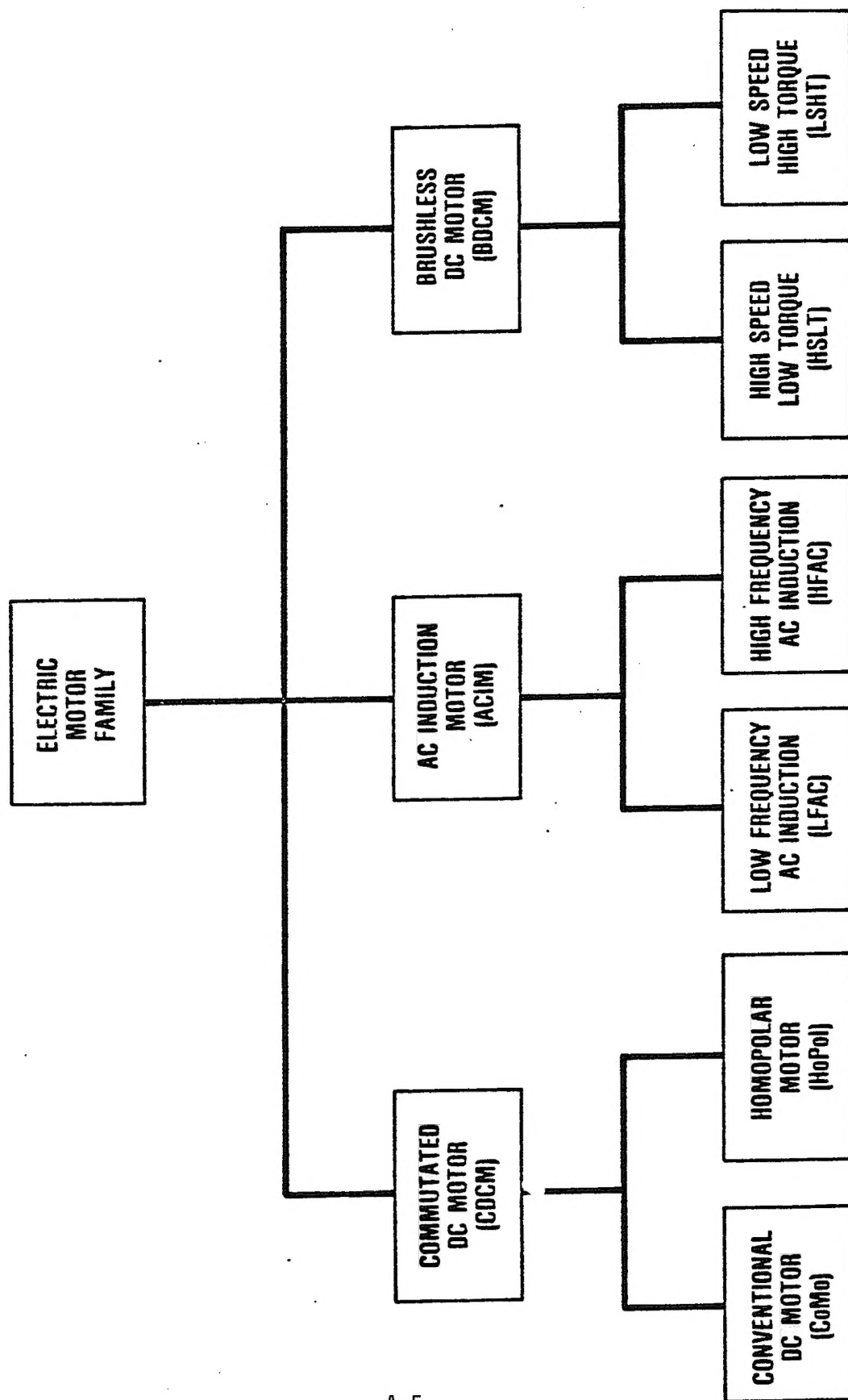


Figure A.2-2 Initial Motor Candidates

ELECTRICAL SYSTEM COMPONENTS



- MOTORS -

ATTRIBUTES	DC (HOMOPOLAR)	AC (INDUCTION)	HYBRID (PERM. MAG.)
PEAK EFFICIENCY	92.8%	95%	95%
SYSTEM VOLTAGE	18-32	200-600	400-600
MAJOR LOSSES	BRUSH I ² R	ROTOR I ² R	STATOR I ² R
OVERLOAD RANGE	14.37/1	14/1	6.4/1
PEAK TORQUE	>1000 LB FT	>1000 LB FT	MAGNET LIMIT
SPEED RANGE	0-15,000	0-15,000	0-15,000
ROTOR INERTIA	LOW	MODERATE	MODERATE
PACKAGING	GOOD	GOOD	GOOD
THERMAL CONTROL	FLOOD COOL	FLOOD COOL	FLOOD COOL
SHOCK/VIBRATION	GOOD	GOOD	MODERATE
RELIABILITY	GOOD	EXCELLENT	MODERATE
TECHNICAL RISK	MODERATE	LOW	HIGH
RELATIVE COST	1.0	1.0	2.0

Figure A.2-3 Selected Motor Candidates

ELECTRICAL SYSTEM COMPONENTS

- MOTOR CONTROLLERS -

ATTRIBUTES	DC (HOMOPOLAR)	AC (INDUCTION)	HYBRID (PERM. MAG.)
EFFICIENCY	> 95%	> 95%	> 95%
CONTROL MODE	VF-PWM	VFAC	VF-PWM
CONTROL RANGE	100%	100%	98%
CONTROL POWER RATIO	2.7%	100%	100%
COMPLEXITY	LOW	MODERATE	HIGH
RELIABILITY	GOOD	MODERATE	MODERATE
POWER SEMICONDUCTORS	NONE	6/3 PHASE	6/3 PHASE
SEMICONDUCTOR LOSSES	LOW	MODERATE	MODERATE
REGENERATIVE	YES	YES	YES
EMI/RFI	LOW	MODERATE	HIGH

Figure A.2-4 Selected Motor Controllers



ELECTRICAL SYSTEM COMPONENTS

- ALTERNATORS/GENERATORS -

CHARACTERISTICS	AC ALTERNATOR (400Hz)	DC GENERATOR (HOPOL)
EFFICIENCY	HIGH - > 93%	HIGH - > 93%
OPERATING SPEED	8000-12000 RPM	10000-14000 RPM
VOLTAGE CONVERSION	RECTIFIER	DIRECT
FIELD CONTROL	YES	YES
REGULATION	GOOD	GOOD
THERMAL CONTROL	SPRAY OIL	FLOOD COOL
REGENERATION	INVERTER/RECTIFIER	BI-DIRECTIONAL
POWER/WEIGHT RATIO	EXCELLENT	GOOD
POWER/VOLUME RATIO	GOOD	GOOD

Figure A.2-5 Selected Alternators/Generators

ELECTRICAL SYSTEM COMPONENTS

-- SEMICONDUCTORS --

PRESENT STATUS

SILICON CONTROLLED RECTIFIER (SCR) - INTEGRATED TRANSISTOR GATE

- * FOCUS ON HIGH VOLTAGE/HIGH CURRENT - UTILITY APPLICATIONS

GATE CONTROLLED RECTIFIER (GTO) - INTEGRATED TRANSISTOR GATE

- * FOCUS ON IMPROVEMENT IN TURN ON/TURN OFF GAIN

BIPOLAR JUNCTION TRANSISTOR (BJT) - INTEGRATED TRANSISTOR BASE

- * FOCUS ON IMPROVING GAIN AT HIGH CURRENTS/HIGH VOLTAGE

FIELD EFFECT TRANSISTOR (FET) - MATERIALS IMPROVEMENT -

- * FOCUS ON REDUCING OHMIC LOSS AND POWER DISSIPATION

PRESENT TREND

MAJOR EMPHASIS IN POWER SEMICONDUCTORS CONTINUES TO BE IN JAPAN. INTRODUCED 1500 VOLT/350 AMP DEVICE.

Figure A.2-6 Power Semiconductors Status



ELECTRICAL SYSTEM COMPONENTS

- MAGNETIC MATERIALS -

MATERIAL	YEAR	ENERGY PRODUCT	IMPACT
SMARIUM COBALT 5	1970	16-18 x 10 ⁶	10-30% REDUCTION
SMARIUM COBALT 217	1978	28-32 x 10 ⁶	PRESENT PRODUCTS
NEODYMIUM-IRON-BORON	1984	45-60 x 10 ⁶	NEW

IREND

PREDUCT 3-5 YEARS FOR NEODYMIUM-IRON TO BE PROMINENT
IN MARKET. SHOWS GOOD PROMISE OF REDUCING COST AND
USE OF CRITICAL MATERIALS. MAJOR PROBLEM WILL BE
PROPER THERMAL CONTROL

Figure A.2-7 Magnetic Material Trends

APPENDIX B

DATA GENERATION REPORTS

B.1 Analytical Methods Used For Performance Analysis

Our performance analysis used validated computer programs to evaluate all significant factors when preparing performance predictions. Existing programs were adapted to meet the specific analysis requirements of this project. These existing programs were based on the principles of SAE recommended practice J688, with appropriate modifications for tracked vehicles. The resulting programs produced the following specified data:

1. Tractive effort vs. speed
2. Acceleration
3. Startability on grades
4. Maximum speed on grades
5. Minimum turn radius vs. speed

The programs were integrated on a conservation of energy basis:

$$[(I) \quad (\text{Input HP} - \text{Loss HP}) * (\text{Drive efficiency}) = \text{Power output}]$$

The input horsepower is the engine horsepower at its operating speed less the appropriate deductions for altitude, temperature, air cleaner, muffler and grills. The loss horsepower includes such items as cooling fan, auxiliary generator, hydraulic pumps and similar parasitic loads. The drive efficiency is measured from engine flywheel to sprocket to fairly assess added losses due to speed up transfer cases to drive high speed generators or high ratio final drives to match high speed motors. The power output to rolling resistance, windage (air resistance), grade resistance and turning losses.

The power budget for the input horsepower is as follows:

1. Rated engine horsepower	500.0
2. Conditions (standard)	- 0.0
3. Air cleaner & muffler	- 5.0
Net input horsepower-----	495.0

The power budget for parasitic losses is as follows:

1. Net input horsepower	495.0
2. Fan (sized for ballistic grills)	-46.2
3. Auxiliary generator	- 5.8
4. Hydraulic pump	- 3.0
Net input horsepower	<hr/> 440.0

The drive efficiency is determined as follows:

1. Generator (or alternator) efficiency is estimated from data for similar items and from manufacturer's estimates. Since these efficiencies are essentially constant at loads over 25% of rating, and the analysis is for full power, a fixed efficiency value is used for all calculations for any given generator type.

2. Power conditioning and control equipment, like the generator, have essentially constant efficiency under normal loads and are therefore also held at a fixed value that is based on data for similar items and on manufacturer's estimates.

3. Motor efficiencies under normal loads are primarily a function of armature speed (RPM). Curve fits have been made with correlation coefficients of at least 0.99 and the resulting equations are used to calculate the efficiency of each motor at each operating point of every operating condition. This detailed approach becomes particularly significant in turns, when each motor has its own individual efficiency at each operating point. Refer to Section 5.1.4.6, Figure 5.1.4.6-B for an example of the differentiations between systems that result from this precise analysis.

4. Power output must equal the sum rolling resistance, wind resistance, grade resistance and turn losses so steady state operation can exist. These values are determined as follows:

o Rolling resistance:

Rolling resistance has been based on a value of 100 pounds per ton, which has been found to be a reasonable value for tracked vehicles on smooth, hard surfaces.

$$[2] \quad RR = GVW / 2000 * Cr$$

Where:

RR = Rolling resistance in pounds

GVW = Gross vehicle weight

Cr = Rolling resistance coefficient

(100 pounds per ton for this study)

o Wind resistance:

Wind resistance has been based on the specified frontal area, a drag coefficient (Cd) of 1.0, vehicle speed in MPH, and a coefficient of 1/391 for standard conditions (ref. Fluid Dynamic Drag, Dr.-Ing. Sighard Hoerner).

These values are used as follows:

$$[3] \quad R_w = A_f * C_d * (MPH^2) / 391$$

Where:

Af = Frontal area in square feet
Cd = Drag coefficient (estimated at 1.0)
MPH = Vehicle speed, miles per hour

o Grade resistance:

Grade resistance is calculated from the basic geometric considerations. The equation used is:

$$[4] \quad R_g = GVW * \sin (A \tan (GR / 100))$$

Where:

Rg = Grade resistance in pounds
GVW = Gross vehicle weight in pounds
GR = Grade in per cent

o Turning losses:

Turning losses consist of power dissipated in scrubbing the tracks around a turn and regeneration losses due to inefficiencies in the regeneration system. These values of scrub horsepower and regenerative horsepower are quantified using methods originated by Merritt and updated in TACOM Technical Report 10969, "Investigation of the Factors Involved in Steering Tracklaying Vehicles". As the method is complex, reference to this report is recommended for those who want the details of the analytical method. The "Scrub Horsepower" is applied directly as a loss. The regeneration loss is found by first determining regeneration efficiency from motor speed and controller efficiency, as is described for drive efficiency. The Transfer Horsepower is then multiplied by the regeneration efficiency to determine the losses due to regeneration.

The above analytical methods have been integrated into a series of programs to solve for specific operating conditions such as tractive effort vs. speed, speed vs. time, speed vs. distance, maximum speed vs. grade, and minimum turning radius vs. speed. In each case the complexity of the calculation necessitates an iterative solution. The appropriate variable is increased until a power balance is reached and the requirements of equation [1] above are met. The performance and load values for that

particular operating point are then printed as required by the contract.

B.2 Data Table Description

The tables in Appendix B provide detailed quantification of the results discussed in the report and the power train load and speed data required by the contract. The following tables tabulate the performance analysis data used in this report. Tables are organized to facilitate comparative analysis by grouping by type of performance, and presenting data for all of the various vehicle and drive types within that group. The data table groups are:

- A. Speed vs. grade and tractive effort
- B. Acceleration
- C. Sprocket and motor speeds and loads for maximum turn condition
- D. Gear speeds and loads at maximum turn condition
- E. Gear speeds and loads at maximum tractive effort condition

Within these groups are performance results for the following vehicle and drive types:

- 1. 19.5 ton, Configuration I, AC induction motor drive system
- 2. 19.5 ton, Configuration II, AC induction motor system
- 3. 19.5 ton, Configuration I, DC homopolar system
- 4. 40 ton, Configuration I, AC induction motor drive system
- 5. 40 ton, Configuration II, AC induction motor drive system
- 6. 40 ton, Configuration I, DC homopolar system

Tables can be easily located by combining the heading letters and numbers from the above listings. As an example, acceleration data for the 19.5 ton, Configuration II, AC induction system is in table B-2.

B.2.A Speed Vs Grade And Tractive Effort Tables

The following tables provide speed vs. grade data plus corresponding sprocket speeds and torques. They are divided into three sections consisting of Title Heading, Data Input and Results. The Title Heading provides in addition to the title, traceability data of program authors, revision data and run date.

The data input section inputs general vehicle description parameters plus operational assumptions such as:

1. Maximum speed: A value of 45 MPH has been used as a contract requirement.
2. Drag coefficient: A value of 1.0 has been used as a reasonable, yet conservative value throughout this study.
3. Rolling resistance: A value of 100 pounds per ton has been used to represent operation on a smooth, hard surface.
4. Engine gross horsepower: Values of 500 and 1000 have been used for the 19.5 and 40 ton vehicles respectively as directed by the contract.
5. Engine loss horsepower: Values of 60 and 120 have been used for the 19.5 and 40 ton vehicles respectively. See Section A.II.1 for a sample loss budget.

The results section of these tables provide the following data:

1. Grade (%): Increments have been selected to provide the range of data specified in the contract.
2. Speed (MPH): This is the maximum speed the vehicle can maintain on the specified grade.
3. Resistance (Pounds): This is the resistance encountered when operating at the stated speed on the stated grade and equals the tractive effort at this limiting condition.
4. Sprocket Torque and RPM: These data can be used to calculate torques and speeds required in related drive-train components.

LIMITING GRADE PERFORMANCE
(FOR ELECTRICAL DRIVE TRACKED VEHICLES)

BY: W.E. RODLER REV. DATE: 11 JUNE 1984
L.M. FERNANDEZ

RUN DATE: 7-AUG-85:11

DATA INPUT:

MAX. VEL., mph = 45.0 ENG. GROSS HP. = 500.0
FRONTAL AREA, sq. ft. = 57.0 ENG. LOSS HP. = 60.0
GROSS VEHICLE WT., lbs = 39000.0 TRACK PITCH, in = 6.03
DRAG COEFFICIENT = 1.00 NO. OF SPROCKET TEETH = 11
ROLLING RESISTANCE, lb per ton = 100.0

Efficiency data for Westinghouse induction motor * CONCEPT I: TWIN
by Craig Joseph 10-MAY-85 * PROPULSION MOTORS

RESULTS:

GRADE(%)	SPEED(mph)	RESISTANCE(lb)	SPROCKET(rpm)	SPROCKET(lbft)
60.00	5.37	22019.54	85.45	9681.58
50.00	6.16	19396.87	98.14	8529.35
40.00	7.40	16442.23	117.89	7229.22
30.00	9.52	13169.79	151.64	5792.50
20.00	13.31	9624.37	211.97	4231.75
15.00	16.68	7775.86	265.63	3418.64
10.00	22.06	5901.62	351.28	2596.11
5.00	32.13	4048.05	511.50	1780.58
4.00	35.23	3689.68	560.86	1623.21
3.00	38.77	3338.64	617.29	1468.80
2.00	42.92	2998.36	683.26	1319.10
1.56	45.00	2853.53	716.42	1254.27

End

LIMITING GRADE PERFORMANCE
(FOR ELECTRICAL DRIVE TRACKED VEHICLES)

BY: W.E. RODLER REV. DATE: 11 JUNE 1984
L.M. FERNANDEZ

RUN DATE: 7-AUG-85:12

DATA INPUT:

MAX. VEL., mph = 45.0 ENG. GROSS HP. = 500.0
FRONTAL AREA, sq. ft. = 57.0 ENG. LOSS HP. = 60.0
GROSS VEHICLE WT., lbs = 39000.0 TRACK PITCH, in = 6.03
DRAG COEFFICIENT = 1.00 NO. OF SPROCKET TEETH = 11
ROLLING RESISTANCE, lb per ton = 100.0

Efficiency data for Westinghouse induction motor * CONCEPT II: PROPULSION/
by Craig Joseph 10-MAY-85 * STEER MOTORS

RESULTS:

GRADE(%)	SPEED(mph)	RESISTANCE(lb)	SPROCKET(rpm)	SPROCKET(lbft)
60.00	5.25	22019.36	83.60	9669.09
50.00	6.02	19396.62	95.86	8528.54
40.00	7.23	16441.86	115.10	7228.49
30.00	9.29	13169.16	147.95	5791.69
20.00	13.02	9623.24	207.27	4231.07
15.00	16.30	7774.02	259.54	3419.66
10.00	21.61	5898.71	344.00	2594.78
5.00	31.49	4042.16	501.40	1777.94
4.00	34.55	3682.75	550.02	1620.11
3.00	38.07	3330.80	606.16	1465.43
2.00	42.18	2989.18	671.48	1315.08
1.40	45.00	2791.15	716.42	1227.59

End

LIMITING GRADE PERFORMANCE
(FOR ELECTRICAL DRIVE TRACKED VEHICLES)

BY: W.E. RODLER REV. DATE: 11 JUNE 1984
L.M. FERNANDEZ

RUN DATE: 7-AUG-85 10

DATA INPUT:

MAX. VEL. = 45.0 ENG. GROSS HP. = 500.0
FRONTAL AREA, sq. ft. = 57.0 ENG. LOSS HP. = 60.0
GROSS VEHICLE WT., lbs = 39000.0 TRACK PITCH, in = 6.03
DRAG COEFFICIENT = 1.00 NO. OF SPROCKET TEETH = 11
ROLLING RESISTANCE, lb per ton = 100.0

Efficiency data for Homopolar motor * CONCEPT I: TWIN
given by Gene Seider 20-MAY-85 *PROPULSION MOTORS

RESULTS:

GRADE(%)	SPEED(mph)	RESISTANCE(lb)	SPROCKET(rpm)	SPROCKET(lb-ft)
60.00	5.07	22019.08	80.70	9669.14
50.00	5.82	19396.27	92.69	8529.64
40.00	7.01	16441.40	111.61	7229.25
30.00	9.05	13168.51	144.08	5790.40
20.00	12.65	9621.84	201.32	4231.09
15.00	15.81	7771.71	251.68	3417.52
10.00	20.91	5894.39	332.90	2592.41
5.00	30.25	4030.99	481.64	1773.07
4.00	33.01	3667.61	525.54	1613.12
3.00	36.16	3310.09	575.68	1456.34
2.00	39.79	2960.62	633.43	1302.65
1.00	43.90	2620.96	698.95	1153.27
0.76	45.00	2541.60	716.42	1118.05

End

LIMITING GRADE PERFORMANCE
(FOR ELECTRICAL DRIVE TRACKED VEHICLES)

BY: W.E. RODLER REV. DATE: 11 JUNE 1984
L.M. FERNANDEZ

RUN DATE: 12-AUG-85:106

DATA INPUT:

MAX. VEL., mph = 45.0 ENG. GROSS HP. = 1000.0
FRONTAL AREA, sq. ft. = 68.3 ENG. LOSS HP. = 120.0
GROSS VEHICLE WT., lbs = 80000.0 TRACK PITCH, in = 7.63
DRAG COEFFICIENT = 1.00 NO. OF SPROCKET TEETH = 11
ROLLING RESISTANCE, lb per ton = 100.0

Efficiency data for Westinghouse induction motor * CONCEPT I: TWIN
by Craig Joseph 10-MAY-85 * PROPULSION MOTORS

RESULTS:

GRADE(%)	SPEED(mph)	RESISTANCE(lb)	SPROCKET(rpm)	SPROCKET(lbft)
60.00	5.22	45164.42	65.74	25114.27
50.00	6.00	39783.36	75.50	22119.23
40.00	7.20	33720.31	90.66	18745.93
30.00	9.26	27002.79	116.54	15016.77
20.00	12.98	19718.71	163.44	10963.23
15.00	16.28	15913.51	204.99	8846.72
10.00	21.64	12042.02	272.41	6695.79
5.00	31.83	8171.84	400.73	4545.70
4.00	35.08	7412.21	441.62	4123.02
3.00	38.86	6662.50	489.24	3706.03
2.00	43.39	5928.26	546.25	3297.71
1.69	45.00	5705.27	566.56	3172.08

End

 LIMITING GRADE PERFORMANCE
 (FOR ELECTRICAL DRIVE TRACKED VEHICLES)

BY: W.E. RODLER REV. DATE: 11 JUNE 1984
 L.M. FERNANDEZ

RUN DATE: 12-AUG-85:107

DATA INPUT:

MAX. VEL. = 45.0 ENG. GROSS HP. = 1000.0
 FRONTAL AREA, sq. ft. = 68.3 ENG. LOSS HP. = 120.0
 GROSS VEHICLE WT., lbs = 80000.0 TRACK PITCH, in = 7.63
 DRAG COEFFICIENT = 1.00 NO. OF SPROCKET TEETH = 11
 ROLLING RESISTANCE, lb per ton = 100.0

 Efficiency data for Westinghouse induction motor * CONCEPT II: PROPULSION/
 by Craig Joseph 10-MAY-85

 RESULTS:

GRADE(%)	SPEED(mph)	RESISTANCE(lb)	SPROCKET(rpm)	SPROCKET(lbft)
60.00	5.11	45164.21	64.29	25091.81
50.00	5.86	39783.07	73.75	22117.27
40.00	7.03	33719.88	88.52	18744.21
30.00	9.03	27002.07	113.72	15014.99
20.00	12.69	19717.42	159.81	10962.05
15.00	15.91	15911.41	200.28	8850.32
10.00	21.18	12038.63	266.72	6693.72
5.00	31.18	8164.74	392.60	4541.53
4.00	34.37	7403.70	432.78	4118.07
3.00	38.13	6652.67	480.03	3700.66
2.00	42.60	5916.42	536.32	3291.05
1.54	45.00	5585.32	566.56	3104.59

 End

LIMITING GRADE PERFORMANCE
(FOR ELECTRICAL DRIVE TRACKED VEHICLES)

BY: W.E. RODLER REV. DATE: 11 JUNE 1984
L.M. FERNANDEZ

RUN DATE: 12-AUG-85:105

DATA INPUT:

MAX. VEL., mph = 45.0 ENG. GROSS HP. = 1000.0
FRONTAL AREA, sq. ft. = 68.3 ENG. LOSS HP. = 120.0
GROSS VEHICLE WT., lbs = 80000.0 TRACK PITCH, in = 7.63
DRAG COEFFICIENT = 1.00 NO. OF SPROCKET TEETH = 11
ROLLING RESISTANCE, lb per ton = 100.0

Efficiency data for Homopolar motor * CONCEPT I: TWIN
Given by Gene Seider 20-MAY-85 * PROPULSION MOTORS

RESULTS:

GRADE(%)	SPEED(mph)	RESISTANCE(lb)	SPROCKET(rpm)	SPROCKET(lbft)
60.00	4.94	45163.93	62.22	25080.66
50.00	5.68	39782.71	71.47	22120.61
40.00	6.83	33719.41	86.03	18746.69
30.00	8.82	27001.42	111.06	15017.98
20.00	12.37	19715.98	155.69	10963.23
15.00	15.50	15909.19	195.18	8846.90
10.00	20.62	12034.51	259.60	6690.93
5.00	30.25	8154.74	380.85	4535.66
4.00	33.20	7389.82	417.98	4110.52
3.00	36.65	6633.36	461.41	3689.80
2.00	40.72	5889.14	512.70	3275.36
1.11	45.00	5241.41	566.56	2912.90

End

B.2.B Acceleration Tables

The following tables provide acceleration data consisting of time, tractive effort, speed, distance and sprocket RPM, torque and horsepower. These tables are divided into three sections consisting of the Title Heading, Data Input and Results. The Title Heading provides in addition to the subject, traceability data of program author, operator, purpose, revision date and run date.

The Data Input section inputs general vehicle description parameters plus operational assumptions such as:

1. Coefficient of drag: a value of 1.0 has been used as a reasonable, yet conservative value throughout this study. This coefficient is multiplied by the frontal area and the velocity head to provide air resistance.
2. Rolling resistance: a value of 100 pounds per ton has been used to represent operation on a smooth, hard surface. This value is multiplied by the gross vehicle weight in tons to obtain vehicle rolling resistance.
3. Coefficient of friction: a value of 0.7 has been used to represent the contact between the track and the roadway. This is used to limit the maximum possible acceleration to the value that the selected adhesive condition will allow.
4. Mass increment for rotation: This value has been calculated from the motor and gear train data. It is input as a fraction of the translational mass of the vehicle. In the calculations, the translational mass of the vehicle is increased by this amount to correct for the rotational inertia of the system.
5. Grade, %: This value is determined by the operating situation. Most calculations have used level (0%), but it was also used to confirm starting performance on a 60% grade.

The results section provides the following acceleration data:

1. Time (seconds): This is cumulative time from the start of the run. As directed by the contract, no allowance is made for throttle response time.
2. Net tractive effort (pounds): This shows the tractive effort available at the corresponding time. It can be either power or adhesion limited.
3. Speed (MPH): This is the instantaneous speed at the given time.
4. Distance (feet): This is the cumulative distance from the start of the run.

5. Sprocket RPM, LB-FT, and HP: These data can be used to calculate speeds, torques and powers required in the related drive train components.

VEHICLE ACCELERATION CHARACTERISTICS

BY: W.E. RODLER
R.E. LEWIS
OPERATOR: R LEWIS
PURPOSE: ELECTRIC DRIVE PROPOSAL
REV. DATE: 31 MAY 1985
RUN DATE: 7-AUG-85:14

DATA INPUT:

GROSS VEHICLE WEIGHT, lbs = 39000.
MAXIMUM VELOCITY, mph = 45.0
ENGINE GROSS HP = 440.0
NUMBER OF SPROCKET TEETH = 11
FRONTAL AREA, in. = 57.0
COEFFICIENT OF DRAG = 1.00
ROLLING RESISTANCE, lb/ton = 100.0
TRACK PITCH, in. = 6.03
COEFFICIENT OF FRICTION = 0.70
MASS INCR. FOR ROT, % = 47.20
GRADE, % = 0.0

Efficiency data for Westinghouse induction motor #CONCEPT I: TWIN DRIVE MOTORS
by Craig Joseph 10-MAY-85

RESULTS:

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
0.10	25350.00	0.00	0.00	0.01	12008.04	0.02
0.20	25349.86	0.97	0.14	15.45	12008.04	35.31
0.30	25349.45	1.94	0.43	30.88	12008.04	70.60
0.40	25348.77	2.91	0.85	46.31	12008.04	105.89
0.50	25347.81	3.88	1.42	61.75	12008.04	141.18
0.60	22818.72	4.85	2.13	77.18	10896.15	160.12
0.70	19467.64	5.72	2.97	91.07	9422.76	163.40
0.80	17206.92	6.46	3.92	102.93	8428.95	165.18
0.90	15602.17	7.12	4.97	113.40	7723.67	166.77
1.00	14383.55	7.72	6.10	122.90	7188.22	168.21
2.00	8926.67	12.07	21.19	192.23	4793.51	175.45
3.00	6837.88	15.08	41.42	240.11	3879.98	177.39
4.00	5682.46	17.48	65.53	278.30	3376.77	178.93

 RESULTS (continued):

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
5.00	4885.13	19.51	92.85	310.60	3030.87	179.24
6.00	4302.27	21.27	122.91	338.66	2779.11	179.20
7.00	3857.91	22.84	155.39	363.58	2588.08	179.16
8.00	3504.53	24.25	190.04	386.06	2436.91	179.13
9.00	3214.72	25.54	226.66	406.58	2313.55	179.10
10.00	2971.43	26.72	265.08	425.46	2210.51	179.07
11.00	2763.38	27.82	305.18	442.97	2122.85	179.05
12.00	2582.82	28.85	346.82	459.29	2047.15	179.02
13.00	2424.18	29.81	389.91	474.57	1980.98	179.00
14.00	2283.37	30.71	434.37	488.93	1922.55	178.98
15.00	2157.31	31.56	480.10	502.48	1870.50	178.96
16.00	2043.59	32.37	527.05	515.30	1823.78	178.94
17.00	1940.35	33.13	575.14	527.46	1781.57	178.92
18.00	1846.08	33.86	624.32	539.01	1743.23	178.91
19.00	1759.58	34.55	674.54	550.01	1708.21	178.89
20.00	1679.86	35.21	725.75	560.50	1676.09	178.87
21.00	1606.09	35.84	777.89	570.52	1646.51	178.86
22.00	1535.51	36.44	830.94	580.11	1618.26	178.74

 RESULTS (continued):

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
23.00	1469.14	37.01	884.85	589.27	1591.77	178.60
24.00	1407.25	37.56	939.59	598.04	1567.18	178.45
25.00	1349.37	38.09	995.11	606.45	1544.29	178.32
26.00	1295.11	38.60	1051.39	614.52	1522.91	178.19
27.00	1244.12	39.09	1108.40	622.26	1502.91	178.07
28.00	1196.12	39.55	1166.10	629.70	1484.15	177.95
29.00	1150.83	40.00	1224.48	636.86	1466.52	177.83
30.00	1108.03	40.44	1283.50	643.75	1449.93	177.72
31.00	1067.51	40.85	1343.14	650.38	1434.28	177.61
32.00	1029.09	41.25	1403.38	656.77	1419.50	177.51
33.00	992.62	41.64	1464.20	662.94	1405.51	177.41
34.00	957.95	42.01	1525.58	668.89	1392.26	177.32
35.00	924.94	42.38	1587.49	674.63	1379.70	177.22
36.00	893.49	42.72	1649.93	680.17	1367.77	177.14
37.00	863.49	43.06	1712.86	685.53	1356.42	177.05
38.00	834.83	43.39	1776.28	690.71	1345.62	176.97
39.00	807.44	43.70	1840.16	695.71	1335.33	176.89
40.00	781.24	44.00	1904.50	700.56	1325.51	176.81

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RESULTS (continued):
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TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
41.00	756.15	44.30	1969.28	705.25	1316.14	176.73
42.00	732.10	44.58	2034.48	709.78	1307.19	176.66
43.00	709.04	44.86	2100.09	714.18	1298.63	176.59
43.50	697.36	45.00	2146.25	716.42	1294.30	176.55

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End
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 VEHICLE ACCELERATION CHARACTERISTICS
 BY: W.E. RODLER
 R.E. LEWIS
 OPERATOR: R. LEWIS
 PURPOSE: ELECTRIC DRIVE PROPOSAL
 REV. DATE: 31 MAY 1985
 RUN DATE: 7-JUL-85:15

DATA INPUT:

GROSS VEHICLE WEIGHT, lbs = 39000.
 MAXIMUM VELOCITY, mph = 45.0
 ENGINE GROSS HP. = 440.0
 NUMBER OF SPROCKET TEETH = 11
 FRONTAL AREA, in. = 57.0
 COEFFICIENT OF DRAG = 1.00
 ROLLING RESISTANCE, lb/ton = 100.0
 TRACK PITCH, in. = 6.03
 COEFFICIENT OF FRICTION = 0.70
 MASS INCR. FOR ROT, % = 47.20
 GRADE, % = 0.0

Efficiency data for Westinghouse Induction motor #CONCEPT II: PROPULSION/STEER MOTOR
 by Craig Joseph 10-MAY-85

RESULTS:

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
0.10	25350.00	0.00	0.00	0.01	12008.04	0.02
0.20	25349.86	0.97	0.14	15.45	12008.04	35.31
0.30	25349.45	1.94	0.43	30.88	12008.04	70.60
0.40	25348.77	2.91	0.85	46.31	12008.04	105.89
0.50	25347.81	3.88	1.42	61.75	12008.04	141.18
0.60	22752.57	4.85	2.13	77.18	10559.16	155.17
0.70	18903.04	5.69	2.97	90.61	9174.39	158.27
0.80	16747.82	6.41	3.91	102.11	8226.97	159.96
0.90	15207.34	7.05	4.94	112.31	7549.93	161.45
1.00	14032.38	7.64	6.06	121.57	7033.67	162.81
2.00	8744.13	11.89	20.95	189.34	4712.94	169.91
3.00	6698.23	14.84	40.86	236.25	3818.09	171.75
4.00	5564.87	17.19	64.57	273.65	3324.40	173.22

 RESULTS (continued):

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
5.00	4789.87	19.18	91.43	305.31	2988.15	173.71
6.00	4216.87	20.91	120.97	332.82	2740.55	173.67
7.00	3780.05	22.44	152.89	357.24	2552.68	173.63
8.00	3432.69	23.82	186.93	379.27	2403.99	173.60
9.00	3147.85	25.08	222.91	399.36	2282.66	173.57
10.00	2908.75	26.25	260.64	417.85	2181.32	173.55
11.00	2704.33	27.32	300.02	434.98	2095.10	173.52
12.00	2526.94	28.33	340.91	450.95	2020.65	173.50
13.00	2371.11	29.26	383.22	465.90	1955.58	173.48
14.00	2232.82	30.15	426.85	479.95	1898.11	173.46
15.00	2109.03	30.98	471.75	493.20	1846.92	173.44
16.00	1997.38	31.77	517.82	505.73	1800.98	173.42
17.00	1896.03	32.51	565.02	517.61	1759.47	173.40
18.00	1803.51	33.22	613.28	528.89	1721.77	173.39
19.00	1718.63	33.90	662.55	539.64	1687.34	173.37
20.00	1640.41	34.54	712.79	549.88	1655.75	173.36
21.00	1568.04	35.15	763.95	559.67	1626.67	173.34
22.00	1500.85	35.74	815.98	569.03	1599.79	173.33

 RESULTS (continued):

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
23.00	1436.85	36.31	868.86	577.99	1574.24	173.25
24.00	1376.04	36.84	922.55	586.57	1550.02	173.11
25.00	1319.18	37.36	977.00	594.79	1527.47	172.99
26.00	1265.89	37.86	1032.20	602.68	1506.41	172.86
27.00	1215.82	38.33	1088.11	610.24	1486.72	172.75
28.00	1168.70	38.79	1144.70	617.52	1468.24	172.63
29.00	1124.24	39.23	1201.94	624.51	1450.89	172.52
30.00	1082.24	39.65	1259.82	631.24	1434.55	172.42
31.00	1042.49	40.06	1318.30	637.72	1419.15	172.32
32.00	1004.81	40.45	1377.37	643.96	1404.60	172.22
33.00	969.04	40.83	1437.00	649.98	1390.83	172.13
34.00	935.04	41.19	1497.17	655.78	1377.80	172.04
35.00	902.68	41.54	1557.87	661.39	1365.43	171.95
36.00	871.85	41.88	1619.08	666.80	1353.69	171.87
37.00	842.44	42.21	1680.77	672.02	1342.52	171.78
38.00	814.36	42.53	1742.94	677.08	1331.90	171.71
39.00	787.53	42.84	1805.57	681.96	1321.77	171.63
40.00	761.86	43.13	1868.63	686.68	1312.12	171.56

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RESULTS (continued):
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TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
41.00	737.29	43.42	1932.13	691.25	1302.90	171.48
42.00	713.74	43.70	1996.03	695.68	1294.10	171.42
43.00	691.16	43.97	2060.34	699.96	1285.68	171.35
44.00	669.50	44.23	2125.04	704.11	1277.62	171.28
45.00	648.70	44.48	2190.11	708.13	1269.91	171.22
46.00	628.71	44.72	2255.54	712.02	1262.52	171.16
47.00	609.49	44.96	2321.33	715.80	1255.43	171.10
47.10	606.35	45.00	2341.13	716.42	1254.27	171.09

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VEHICLE ACCELERATION CHARACTERISTICS

BY: W.E. RODLER
R.E. LEWIS
OPERATOR: R LEWIS
PURPOSE: ELECTRIC DRIVE PROPOSAL
REV. DATE: 31 MAY 1985
RUN DATE: 7-AUG-85:13

DATA INPUT:

GROSS VEHICLE WEIGHT, lbs = 39000.
MAXIMUM VELOCITY, mph = 45.0
ENGINE GROSS HP = 440.0
NUMBER OF SPROCKET TEETH = 11
FRONTAL AREA, in. = 57.0
COEFFICIENT OF DRAG = 1.00
ROLLING RESISTANCE, lb/ton = 100.0
TRACK PITCH, in. = 6.03
MASS INCR. FOR ROT, % = 28.40
GRADE, % = 0.0
COEFFICIENT OF FRICTION = 0.70

Efficiency data for Homopolar motor #CONCEPT 1: TWIN DRIVE MOTORS
given by Gene Seider 20-MAY-85

RESULTS:

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
0.10	25350.00	0.00	0.00	0.01	12008.04	0.02
0.20	25349.82	1.11	0.16	17.70	12008.04	40.48
0.30	25349.28	2.22	0.49	35.40	12008.04	80.93
0.40	25348.38	3.33	0.98	53.09	12008.04	121.39
0.50	23687.38	4.45	1.63	70.79	11242.81	151.53
0.60	19175.76	5.48	2.43	87.26	9294.20	154.42
0.70	16631.74	6.32	3.36	100.65	8175.83	156.68
0.80	14916.52	7.05	4.40	112.26	7422.01	158.64
0.90	13654.31	7.71	5.53	122.67	6867.44	160.40
1.00	12671.76	8.30	6.74	132.20	6435.88	162.00
2.00	7907.54	12.71	22.73	202.31	4346.24	167.42
3.00	6052.60	15.77	43.94	250.99	3535.92	168.98
4.00	5000.64	18.19	69.08	289.66	3078.50	169.78

 RESULTS (continued):

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
5.00	4277.75	20.23	97.45	322.14	2765.56	169.63
6.00	3756.23	22.00	128.58	350.27	2540.95	169.46
7.00	3355.93	23.57	162.13	375.18	2369.45	169.26
8.00	3036.46	24.97	197.85	397.56	2233.31	169.05
9.00	2772.28	26.25	235.52	417.90	2121.30	168.79
10.00	2550.06	27.42	274.97	436.53	2027.58	168.53
11.00	2359.36	28.50	316.07	453.71	1947.57	168.25
12.00	2194.10	29.50	358.68	469.65	1878.60	167.99
13.00	148.68	30.43	402.71	484.50	1818.23	167.73
14.00	1918.70	31.30	448.05	498.38	1764.51	167.44
15.00	1799.76	32.12	494.63	511.39	1715.51	167.04
16.00	1692.13	32.89	542.37	523.61	1671.37	166.63
17.00	1594.87	33.61	591.19	535.11	1631.67	166.25
18.00	1506.46	34.29	641.05	545.96	1595.75	165.88
19.00	1425.31	34.94	691.87	556.22	1562.92	165.52
20.00	1349.89	35.55	743.60	565.93	1532.50	165.13
21.00	1280.22	36.13	796.21	575.13	1504.51	164.75
22.00	1215.02	36.67	849.64	583.85	1478.39	164.35

 RESULTS (continued):

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
23.00	1154.66	37.19	903.85	592.14	1454.31	163.97
24.00	1098.61	37.69	958.80	600.02	1432.03	163.60
25.00	1046.41	38.16	1014.46	607.53	1411.36	163.26
26.00	1002.02	38.61	1070.80	614.69	1394.05	163.16
27.00	954.99	39.04	1127.77	621.53	1375.50	162.78
28.00	910.96	39.45	1185.37	628.06	1358.20	162.42
29.00	869.67	39.84	1243.54	634.29	1342.03	162.08
30.00	830.87	40.21	1302.28	640.23	1326.88	161.75
31.00	794.29	40.57	1361.55	645.92	1312.64	161.43
32.00	759.56	40.91	1421.33	651.35	1299.15	161.12
33.00	726.80	41.24	1481.61	656.55	1286.46	160.82
34.00	695.84	41.55	1542.34	661.52	1274.50	160.53
35.00	566.56	41.85	1603.53	666.29	1263.22	160.26
36.00	638.82	42.14	1665.14	670.85	1252.56	159.99
37.00	612.52	42.41	1727.17	675.23	1242.48	159.74
38.00	587.56	42.68	1789.59	679.42	1232.94	159.50
39.00	563.85	42.93	1852.39	683.45	1223.90	159.27
40.00	541.30	43.17	1915.55	687.31	1215.32	159.05

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RESULTS (continued):
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TIME   NET T.E.   SPEED   DISTANCE   SPROCKET   SPROCKET   SPROCKET
(sec)  (lbs)  (mph)  (ft)      (rpm)      (lb-ft each) (hp each)
41.00  19.84  43.40  1979.05   691.02     1207.18     158.83
42.00  499.41  43.63  2042.90   694.59     1199.44     158.63
43.00  479.93  43.84  2107.06   698.01     1192.08     158.43
44.00  461.36  44.05  2171.53   701.30     1185.07     158.24
45.00  443.63  44.25  2236.30   704.47     1178.40     158.06
46.00  426.70  44.44  2301.35   707.51     1172.04     157.89
47.00  410.52  44.62  2366.68   710.44     1165.98     157.72
48.00  395.06  44.80  2432.27   713.25     1160.19     157.56
49.00  380.26  44.97  2498.12   715.96     1154.66     157.41
49.10  377.79  45.00  2517.92   716.42     1153.74     157.38
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End
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VEHICLE ACCELERATION CHARACTERISTICS

BY: W.E. ROOLER
R.E. LEWIS
OPERATOR: R LEWIS
PURPOSE: ELECTRIC DRIVE PROPOSAL
REV. DATE: 31 MAY 1985
RUN DATE: 12-AUG-85:101

DATA INPUT:

GROSS VEHICLE WEIGHT, lbs = 80000.
MAXIMUM VELOCITY, mph = 45.0
ENGINE NET HP. = 880.0
NUMBER OF SPROCKET TEETH = 11
FRONTAL AREA, in. = 68.3
COEFFICIENT OF DRAG = 1.00
ROLLING RESISTANCE, lb/ton = 100.0
TRACK PITCH, in. = 7.63
COEFFICIENT OF FRICTION = 0.70
MASS INCR. FOR ROT, % = 47.20
GRADE, % = 0.0

Efficiency data for Westinghouse induction motor #CONCEPT I: TWIN DRIVE MOTORS
by Craig Joseph 10-MAY-85

RESULTS:

TIME (sec)	NET T.C. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
0.10	52000.00	0.00	0.00	0.01	31147.28	0.05
0.20	51999.84	0.97	0.14	12.21	31147.29	72.44
0.30	51999.34	1.94	0.43	24.42	31147.28	144.82
0.40	51998.52	2.91	0.85	36.63	31147.28	217.21
0.50	51997.38	3.88	1.42	48.83	31147.28	289.59
0.60	45339.65	4.85	2.13	61.04	27556.31	320.24
0.70	39001.55	5.70	2.97	71.73	23920.67	326.68
0.80	34560.13	6.42	3.91	80.88	21440.08	330.17
0.90	31355.77	7.07	4.95	88.99	19669.78	333.27
1.00	28929.23	7.65	6.07	96.35	18320.97	336.09
2.00	18022.87	11.93	20.99	150.20	12262.97	350.71
3.00	13816.69	14.89	40.98	187.49	9931.20	354.53
4.00	11490.17	17.26	64.78	217.25	8644.56	357.58

 RESULTS (continued):

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
5.00	9897.58	19.26	91.74	242.45	7765.85	358.50
6.00	8724.48	21.00	121.41	264.38	7120.18	358.42
7.00	7831.26	22.55	153.48	283.87	6629.92	358.34
8.00	7121.83	23.94	187.69	301.47	6241.64	358.28
9.00	6540.77	25.22	223.86	317.55	5924.55	358.22
10.00	6053.56	26.40	261.81	322.38	5659.47	358.16
11.00	5637.45	27.49	301.42	346.13	5433.74	358.11
12.00	5276.73	28.51	342.57	358.97	5238.66	358.06
13.00	4960.16	29.47	385.17	371.02	5067.96	358.02
14.00	4679.47	30.37	429.12	382.36	4917.08	357.98
15.00	4428.41	31.22	474.36	393.07	4782.52	357.94
16.00	4202.15	32.03	520.80	403.22	4661.63	357.90
17.00	3996.91	32.79	568.40	412.87	4552.29	357.86
18.00	3809.66	33.52	617.09	422.05	4452.84	357.83
19.00	3637.96	34.22	666.82	430.80	4361.92	357.79
20.00	3479.82	34.88	717.54	439.17	4278.42	357.76
21.00	3333.56	35.52	769.22	447.19	4201.42	357.73
22.00	3196.57	36.13	821.81	454.86	4129.46	357.64

RESULTS (continued):

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
23.00	3064.76	36.71	875.27	462.23	4060.29	357.35
24.00	2941.88	37.27	929.57	469.29	3995.97	357.06
25.00	2827.00	37.81	984.68	476.07	3936.00	356.78
26.00	2719.31	38.33	1040.56	482.59	3879.94	356.52
27.00	2618.14	38.83	1097.18	488.87	3827.40	356.26
28.00	2522.87	39.31	1154.52	494.91	3778.05	356.02
29.00	2432.99	39.77	1212.55	500.74	3731.61	355.78
30.00	2348.04	40.22	1271.24	506.36	3687.83	355.55
31.00	2267.60	40.65	1330.58	511.78	3646.47	355.33
32.00	2191.31	41.07	1390.54	517.02	3607.34	355.12
33.00	2118.86	41.47	1451.09	522.09	3570.27	354.91
34.00	2049.95	41.86	1512.23	526.99	3535.09	354.71
35.00	1984.32	42.23	1573.92	531.73	3501.66	354.52
36.00	1921.75	42.60	1636.16	536.32	3469.86	354.33
37.00	1862.02	42.95	1698.93	540.77	3439.57	354.15
38.00	1804.94	43.29	1762.20	545.08	3410.69	353.98
39.00	1750.34	43.63	1825.97	549.26	3383.12	353.81
40.00	1698.06	43.95	1890.21	553.31	3356.78	353.65

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RESULTS (continued):
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TIME      NET T.E.      SPEED      DISTANCE      SPROCKET      SPROCKET      SPROCKET
(sec)     (lbs)     (mph)     (ft)         (rpm)         (lb-ft each) (hp each)
41.00     1647.96   44.26     1954.92      557.24      3331.59      353.49
42.00     1599.90   44.56     2020.08      561.06      3307.47      353.33
43.00     1553.77   44.86     2085.68      564.77      3284.37      353.18
43.40     1531.66   45.00     2125.24      566.56      3273.32      353.11
*****
End
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VEHICLE ACCELERATION CHARACTERISTICS

BY: W.E. RODLER
R.E. LEWIS

OPERATOR: R LEWIS
PURPOSE: ELECTRIC DRIVE PROPOSAL

REV. DATE: 31 MAY 1985
RUN DATE: 12-AUG-85:102

DATA INPUT:

GROSS VEHICLE WEIGHT, lbs = 80000.
MAXIMUM VELOCITY, mph = 45.0
ENGINE NET HP. = 880.0
NUMBER OF SPROCKET TEETH = 11
FRONTAL AREA, in. = 68.3

COEFFICIENT OF DRAG = 1.00
ROLLING RESISTANCE, lb/ton = 100.0
TRACK PITCH, in. = 7.63
COEFFICIENT OF FRICTION = 0.70

MASS INCR. FOR ROT, % = 47.20
GRADE, % = 0.0

Efficiency data for Westinghouse induction motor #CONCEPT II: PROPULSION/STEER MOTOR
by Craig Joseph 10-MAY-85

RESULTS:

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
0.10	52000.00	0.00	0.00	0.01	31147.28	0.05
0.20	51999.84	0.97	0.14	12.21	31147.28	72.44
0.30	51999.34	1.94	0.43	24.42	31147.28	144.82
0.40	51998.52	2.91	0.85	36.63	31147.28	217.21
0.50	51997.38	3.88	1.42	48.83	31147.28	289.59
0.60	44007.37	4.85	2.13	61.04	26704.05	310.34
0.70	37863.94	5.67	2.96	71.37	23287.90	316.44
0.80	33612.46	6.37	3.90	80.25	20924.05	319.73
0.90	30356.95	7.00	4.93	88.14	19225.38	322.65
1.00	28218.30	7.57	6.04	95.32	17925.43	325.32
2.00	17652.18	11.75	20.75	147.96	12056.38	339.64
3.00	13532.98	14.65	40.42	184.47	9772.71	343.26
4.00	11251.00	16.97	63.83	213.62	8510.58	346.16

 RESULTS (continued):

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
5.00	9703.37	18.93	90.34	238.31	7656.62	347.43
6.00	8530.02	20.64	119.50	259.81	7021.68	347.35
7.00	7671.83	22.15	151.01	278.90	6539.54	347.28
8.00	6974.38	23.52	184.62	296.15	6157.68	347.22
9.00	6403.17	24.77	220.14	311.89	5845.84	347.16
10.00	5924.27	25.93	257.42	326.40	5585.15	347.11
11.00	5515.30	26.99	296.31	339.86	5363.17	347.06
12.00	5160.80	27.99	336.72	352.43	5171.32	347.01
13.00	4849.74	28.93	378.53	364.20	5003.48	346.97
14.00	4573.96	29.81	421.68	375.29	4855.11	346.93
15.00	4327.33	30.64	466.07	385.76	4722.82	346.89
16.00	4105.09	31.43	511.65	395.68	4603.95	346.86
17.00	3903.53	32.18	558.35	405.10	4496.47	346.82
18.00	3719.66	32.89	606.12	414.06	4398.70	346.79
19.00	3551.09	33.57	654.91	422.61	4309.32	346.76
20.00	3395.85	34.22	704.67	430.78	4227.24	346.73
21.00	3252.30	34.84	755.36	438.60	4151.56	346.70
22.00	3119.08	35.43	806.93	446.09	4081.52	346.67

 RESULTS (continued):

TIME (sec)	NET T.F. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
23.00	2995.01	36.00	859.36	453.28	4016.48	346.65
24.00	2874.20	36.55	912.61	460.18	3953.14	346.37
25.00	2761.28	37.08	966.65	466.81	3894.10	346.11
26.00	2655.45	37.58	1021.44	473.17	3838.90	345.86
27.00	2556.04	38.07	1076.95	479.30	3787.19	345.62
28.00	2462.46	38.54	1133.17	485.20	3738.62	345.39
29.00	2374.19	38.99	1190.06	490.89	3692.92	345.16
30.00	2290.77	39.43	1247.59	496.37	3649.84	344.95
31.00	2211.79	39.85	1305.76	501.66	3609.15	344.74
32.00	2136.91	40.25	1364.53	506.77	3570.66	344.54
33.00	2065.81	40.64	1423.88	511.71	3534.19	344.34
34.00	1998.20	41.02	1483.80	516.49	3499.59	344.16
35.00	1933.82	41.39	1544.27	521.11	3466.72	343.97
36.00	1872.44	41.75	1605.26	525.59	3435.46	343.80
37.00	1813.87	42.09	1666.77	529.92	3405.68	343.63
38.00	1757.91	42.42	1728.77	534.12	3377.29	343.46
39.00	1704.38	42.75	1791.25	538.19	3350.19	343.30
40.00	1653.14	43.06	1854.20	542.13	3324.30	343.15

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RESULTS (continued):
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TIME    NET T.E.    SPEED    DISTANCE    SPROCKET    SPROCKET    SPROCKET
(sec)   (lbs)   (mph)   (ft)   (rpm)   (lb-ft each)   (hp each)

41.00   1604.04   43.36   1917.60   545.96   3299.54   343.00

42.00   1556.96   43.66   1981.44   549.68   3275.85   342.85

43.00   1511.77   43.95   2045.71   553.28   3253.15   342.71

44.00   1468.36   44.22   2110.38   556.78   3231.39   342.57

45.00   1426.64   44.49   2175.47   560.19   3210.51   342.44

46.00   1386.50   44.76   2240.94   563.49   3190.46   342.31

46.90   1349.65   45.00   2313.39   566.56   3172.08   342.19

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End
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VEHICLE ACCELERATION CHARACTERISTICS

BY: W.E. RODLER
R.E. LEWIS

OPERATOR: R. LEWIS
PURPOSE: ELECTRIC DRIVE PROPOSAL

REV. DATE: 31 MAY 1985
RUN DATE: 12-AUG-85:100

DATA INPUT:

GROSS VEHICLE WEIGHT, lbs = 80000.
MAXIMUM VELOCITY, mph = 45.0
ENGINE NET HP = 890.0
NUMBER OF SPROCKET TEETH = 11
FRONTAL AREA, in. = 68.3

COEFFICIENT OF DRAG = 1.00
ROLLING RESISTANCE, lb/ton = 100.0
TRACK PITCH, in. = 7.63
COEFFICIENT OF FRICTION = 0.70

MASS INCR. FOR RDT, % = 24.60
GRADE, % = 0.0

Efficiency data for Homopolar motor
given by Gene Seider 20-MAY-85

RESULTS:

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
0.10	39335.36	0.00	0.00	0.01	24103.19	0.04
0.20	51999.87	0.87	0.13	10.92	31147.28	64.74
0.30	51999.29	2.01	0.42	25.34	31147.28	150.25
0.40	51998.26	3.16	0.89	39.76	31147.28	235.77
0.50	48629.70	4.30	1.52	54.17	29274.51	301.97
0.60	39115.36	5.37	2.30	67.66	23983.62	308.97
0.70	33717.80	6.24	3.22	78.51	20982.47	313.64
0.80	30135.19	6.98	4.24	87.86	18990.77	317.68
0.90	27522.85	7.64	5.36	96.21	17538.72	321.29
1.00	25503.21	8.25	6.57	103.84	16416.34	324.59
2.00	15833.50	12.69	22.52	159.75	11047.05	336.02
3.00	12109.34	15.76	43.71	198.46	8984.16	339.49
4.00	10005.39	18.20	68.85	229.19	7821.99	341.35

 RESULTS (continued):

TIME (sec)	NET T-E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
5.00	8565.49	20.26	97.25	255.02	7028.78	341.30
6.00	7529.85	22.03	128.42	277.41	6460.05	341.22
7.00	6736.09	23.61	162.03	297.26	6025.55	341.04
8.00	6103.65	25.03	197.82	315.12	5680.48	340.83
9.00	5583.48	26.32	235.58	331.37	5397.60	340.56
10.00	5146.07	27.51	275.15	346.29	5160.50	340.26
11.00	4771.14	28.60	316.39	360.08	4957.93	339.92
12.00	4446.47	29.62	359.16	372.90	4783.11	339.61
13.00	4151.17	30.57	403.38	384.86	4629.97	339.28
14.00	3907.59	31.46	448.94	396.08	4494.30	338.94
15.00	3673.79	32.30	495.76	406.62	4369.44	338.29
16.00	3463.53	33.08	543.77	416.54	4257.49	337.66
17.00	3273.49	33.83	592.90	425.90	4156.62	337.07
18.00	3100.72	34.53	643.08	434.76	4065.20	336.52
19.00	2941.89	35.20	694.27	443.16	3981.37	335.94
20.00	2795.65	35.83	746.41	451.13	3904.40	335.37
21.00	2659.13	36.43	799.45	458.71	3832.69	334.75
22.00	2532.35	37.01	853.36	465.92	3766.26	334.12

 RESULTS (continued):

TIME (sec)	NET T.E. (lbs)	SPEED (mph)	DISTANCE (ft)	SPROCKET (rpm)	SPROCKET (lb-ft each)	SPROCKET (hp each)
23.00	2414.85	37.55	908.08	472.79	3704.86	333.52
24.00	2305.60	38.07	963.58	479.35	3647.92	332.95
25.00	2208.23	38.57	1019.82	485.62	3597.47	332.64
26.00	2111.44	39.05	1076.78	491.62	3547.23	332.04
27.00	2020.83	39.50	1134.42	497.36	3500.31	331.48
28.00	1935.83	39.94	1192.71	502.86	3456.39	330.94
29.00	1855.92	40.36	1251.63	508.13	3415.21	330.42
30.00	1780.18	40.76	1311.15	513.18	3376.24	329.90
31.00	1708.51	41.15	1371.25	518.02	3339.44	329.38
32.00	1640.82	41.51	1431.89	522.68	3304.76	328.89
33.00	1576.79	41.87	1493.07	527.15	3272.02	328.41
34.00	1516.15	42.21	1554.75	531.44	3241.07	327.96
35.00	1458.63	42.54	1616.93	535.57	3211.78	327.52
36.00	1404.02	42.85	1679.58	539.55	3184.02	327.10
37.00	1352.10	43.16	1742.68	543.38	3157.69	326.70
38.00	1302.69	43.45	1806.22	547.06	3132.67	326.31
39.00	1255.62	43.73	1870.17	550.62	3108.88	325.93
40.00	1210.75	44.01	1934.54	554.04	3086.24	325.57

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RESULTS (continued):
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TIME   NET T.E.   SPEED   DISTANCE   SPROCKET   SPROCKET   SPROCKET
(sec)  (lbs)         (mph)    (ft)       (rpm)      (lb-ft each) (hp each)
41.00  1167.92      44.27   1999.29    557.35     3064.66     325.22
42.00   ? 27.02    44.52   2064.42    560.53     3044.10     324.89
43.00  1087.92      44.77   2129.92    563.61     3024.47     324.57
43.90  1050.80      45.00   2202.37    566.56     3005.86     324.26
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End
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B.2.C Maximum Turn Conditions

The following tables provide drivetrain data for a vehicle in a turn. These tables are divided into three sections consisting of Title Heading, Data Input and Results. The Title Heading provides in addition to the title, traceability data of program authors, revision data and run date.

The data input section is generally similar to the previous sections except that an input titled "Maximum Acceleration" has been added. This input is the maximum lateral acceleration that the vehicle is to develop in a turn. For this study, a value of 0.5 has been used as representative of aggressive but not reckless driving.

The Results section provides the following data:

1. Vehicle speed in 1.5 MPH increments to 45 MPH.
2. Lateral acceleration in G's, limited either by available power or by the selected maximum.
3. Turn radius in feet measured to the centerline of the vehicle.
4. Data for inner and outer sprockets is presented in four columns each as follows:
 - a. Apparent horsepower is the combined power at the sprocket and is the value that would be determined by use of a torque meter and RPM counter.
 - b. Propulsion horsepower is the fraction of the apparent power that is used to propel the vehicle.
 - c. Sprocket RPM with a negative sign indicates reverse rotation.
 - d. Sprocket torque with a negative sign indicates a retarding rather than driving torque.
5. Scrub horsepower is the power loss due to scrubbing the tracks around a turn and power flow is always from the vehicle to the tracks.
6. Transfer horsepower is the regenerated power that enters the inner sprocket, is transferred by the drive train to the outer sprocket.

RUN DATE: 7-AUG-85:2

DATA INPUT:

GROSS VEHICLE WEIGHT, tons = 19.5
TREAD WIDTH, in. = 92.5
TRACK LENGTH, in. = 150.0
MAXIMUM VELOCITY, mph = 45.0
TRACK PITCH, in. = 6.03
ENGINE GROSS HP. = 500.0
NUMBER OF SPROCKET TEETH = 11
LOSS ENGINE HP. = 60.0
ROLLING RESISTANCE, lb per ton = 100.0
FRONTAL AREA, in. = 57.0
GRADE, % = 0.0
COEFFICIENT OF FRICTION = 0.70
MAXIMUM ACCELERATION, g's = 0.50
COEFFICIENT OF DRAG = 1.00

Efficiency data for Westinghouse induction motor * CONCEPT I: TWIN PROPULSION MOTORS *
by Craig Joseph 10-MAY-85

RESULTS:

VEH	*LATERAL*	*TURN	*INER	*SPOCKET	*OUTER	*SPOCKET	*TORQUE	*SCRUB				
*SPEED	*ACCEL	*RADIUS*	*APPARNT*	*PROP	*APPARNT*	*PROP	*TORQUE	*TRANSFR*				
(mph)	(g/s)	(ft)	HP	RPM	HP	RPM	(ftlbs)*	HP				
0.00*	0.000*	0.00*	175.31*	15.4*	-94.1*	-9783.3*	175.37*	15.4*	94.1*	9783.3*	160.0*	0.0
1.50*	0.089*	1.69*	121.28*	10.7*	-65.8*	-9686.7*	209.37*	18.5*	113.52*	9686.7*	150.7*	40.1
3.00*	0.071*	8.49*	-17.47*	2.0*	12.1*	-7591.5*	147.87*	13.6*	83.44*	9308.1*	57.4*	76.8
4.50*	0.151*	8.97*	-30.20*	3.4*	21.0*	-7564.9*	216.19*	20.0*	122.32*	9283.0*	81.3*	114.9
6.00*	0.256*	9.40*	-44.55*	5.1*	31.0*	-7540.8*	282.15*	26.2*	160.02*	9260.8*	103.2*	152.8
7.50*	0.360*	10.4*	-66.93*	7.7*	47.0*	-7482.0*	335.19*	31.5*	191.83*	9204.7*	115.1*	189.7
9.00*	0.434*	12.47*	-98.82*	11.6*	70.4*	-7372.9*	374.50*	35.5*	216.17*	9098.8*	114.3*	224.7
10.50*	0.500*	14.75*	-131.49*	15.7*	95.2*	-7251.1*	408.83*	39.4*	239.09*	8980.7*	111.1*	258.3
12.00*	0.500*	19.26*	-171.14*	21.1*	128.1*	-7016.1*	423.13*	41.9*	253.98*	8750.1*	94.5*	286.7
13.50*	0.500*	24.38*	-204.56*	26.3*	159.0*	-6757.8*	438.20*	44.8*	270.87*	8496.7*	81.2*	312.1
15.00*	0.500*	30.10*	-232.48*	31.3*	188.5*	-6479.0*	452.73*	48.0*	289.15*	8223.3*	70.5*	334.2
16.50*	0.500*	36.42*	-255.34*	36.1*	216.9*	-6182.4*	465.89*	51.4*	308.46*	7932.7*	61.5*	353.0
18.00*	0.500*	43.34*	-273.43*	40.9*	244.6*	-5870.9*	477.14*	55.0*	328.52*	7628.0*	53.9*	368.3
19.50*	0.500*	50.86*	-287.01*	45.6*	271.7*	-5547.7*	486.12*	58.6*	349.18*	7311.9*	47.4*	380.1

SPROCKET HORSEPOWER RUN DATE: No. 7-AUG-85:2

VEH #	LATERAL* TURN *	INNER SPROCKET	* TORQUE	* APPARNT*	OUTER SPROCKET	* TORQUE	* APPARNT*	SCRUB	* TRANSFER*			
SPEED *	ACCEL #	RPM	HP	PROP *	RPM	HP	PROP *	HP	HP			
(mph) *	(gs) *	(ft)	HP	(ftlbs)*	HP	(ftlbs)*	HP	(ftlbs)*				
21.00*	0.500*	58.99*	296.29*	50.3*	298.4*	5215.6*	492.65*	62.5*	370.29*	6987.6*	41.8*	388.4
22.50*	0.500*	67.72*	301.49*	55.0*	324.6*	4877.5*	496.63*	66.4*	391.77*	6657.8*	36.9*	393.4
24.00*	0.500*	77.05*	302.83*	59.7*	350.6*	4536.2*	498.08*	70.4*	413.56*	6325.6*	32.5*	395.1
25.50*	0.500*	86.98*	300.57*	64.5*	376.4*	4194.5*	497.07*	74.6*	435.59*	5993.4*	28.7*	393.7
27.00*	0.500*	97.51*	294.97*	69.2*	401.9*	3855.0*	493.72*	78.8*	457.82*	5663.9*	25.3*	389.5
28.50*	0.500*	108.65*	286.32*	74.0*	427.2*	3519.9*	488.22*	83.2*	480.23*	5339.5*	22.3*	382.7
30.00*	0.500*	120.38*	274.92*	78.9*	452.4*	3191.3*	480.78*	87.6*	502.79*	5022.2*	19.7*	373.5
31.50*	0.500*	132.72*	261.06*	83.8*	477.5*	2871.3*	471.63*	92.2*	525.47*	4714.0*	17.3*	362.1
33.00*	0.500*	145.66*	245.06*	88.7*	502.5*	2561.4*	461.04*	96.8*	548.26*	4416.6*	15.2*	349.0
34.50*	0.500*	159.21*	227.25*	93.8*	527.4*	2263.2*	449.26*	101.6*	571.14*	4131.3*	13.3*	336.4
36.00*	0.500*	173.35*	207.91*	98.9*	552.2*	1977.7*	436.57*	106.4*	594.11*	3859.3*	11.7*	318.5
37.50*	0.500*	188.10*	187.37*	104.1*	576.9*	1705.9*	423.22*	111.4*	617.15*	3601.7*	10.2*	301.7
39.00*	0.500*	203.45*	165.89*	109.4*	601.5*	1448.4*	409.47*	116.5*	640.26*	3358.9*	8.9*	284.2
40.50*	0.500*	219.40*	143.75*	114.8*	626.1*	1205.8*	395.58*	121.6*	663.42*	3131.6*	7.7*	266.2
42.00*	0.500*	235.95*	121.20*	120.3*	650.7*	978.3*	381.75*	126.9*	686.64*	2920.0*	6.7*	248.2
43.50*	0.500*	253.11*	98.47*	125.9*	675.2*	766.0*	368.20*	132.3*	709.90*	2724.1*	5.8*	230.1
45.00*	0.500*	270.86*	75.75*	131.6*	699.6*	568.7*	355.12*	137.9*	733.20*	2543.8*	5.0*	212.3

End

SPROCKET HORSEPOWER
BY: W.E. ROLLER REV. DATE: 13 JUNE 1985
R.E. LEWIS

RUN DATE: 7-AUG-85:13

DATA INPUT:

GROSS VEHICLE WEIGHT, tons = 19.5 TREAD WIDTH, in. = 92.5 GRADE, % = 0.0
MAXIMUM VELOCITY, mph = 45.0 TRACK LENGTH, in. = 150.0 COEFFICIENT OF FRICTION = 0.70
ENGINE GROSS HP = 500.0 TRACK PITCH, in. = 6.03 MAXIMUM ACCELERATION, g = 0.50
LOSS ENGINE HP = 60.0 NUMBER OF SPROCKET TEETH = 11 COEFFICIENT OF DRAG = 1.00
FRONTAL AREA, ft² = 57.0 ROLLING RESISTANCE, lb per ton = 100.0 PROPULSION MOTOR EFF, % = 94.
STEER MOTOR EFF, % = 92. STEER SYS. GEAR RATIO = 99:1 PROP. SYS. GEAR RATIO = 21:1

Efficiency data for Westinghouse induction motor * CONFIGURATION II
by Craig Joseph 10-MAY-85 PROPULSION/STEER MOTOR SET-UP

RESULTS:

VEH. * SPEED (mph)	*LAT. * TURN (deg)	*TURN (ft)	*INNER SPROCKET RPM	*INNER SPROCKET HP	*INNER SPROCKET TORQUE (lbft)	*OUTER SPROCKET RPM	*OUTER SPROCKET HP	*OUTER SPROCKET TORQUE (lbft)	*STEER MOTOR RPM	*STEER MOTOR TORQUE (lbft)	*STEER MOTOR HP	*PROPULSION MOTOR RPM	*PROPULSION MOTOR TORQUE (lbft)	*PROPULSION MOTOR HP	*SCRU*TRANS TORQUE (lbft)	*SCRU*TRANS HP
0.00	0.0000	0.00	113.4	9.9	60.9	9783.1	266.6	6064.9	213.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.50	0.0740	2.03	93.2	8.3	50.7	9667.3	177.9	16.1	98.4	9496.2	295.6	7423.7	209.1	-0.8	503.6	-8.6
3.00	0.1490	4.04	49.6	4.5	27.3	9554.5	217.1	20.1	122.8	9283.9	292.5	7473.5	205.6	-2.6	1007.3	-13.6
4.50	0.2240	6.04	6.4	0.6	-3.6	9443.5	254.7	24.0	146.0	9108.4	288.7	7490.1	202.5	-4.9	1510.9	-16.9
6.00	0.2990	8.05	-29.3	3.3	20.2	-7614.0	291.2	28.0	170.8	8955.0	258.2	7498.4	180.8	25.9	2014.6	67.6
7.50	0.3730	10.08	-63.2	7.3	4.3	-7502.4	326.5	31.9	194.5	8814.4	253.7	7483.3	178.1	31.7	2518.2	66.2
9.00	0.4480	12.09	-95.8	11.2	68.1	-7393.3	361.3	35.9	218.5	8686.0	250.2	7489.9	175.5	37.5	3021.9	65.2
10.50	0.5000	14.74	-131.5	15.7	95.2	-7251.3	388.2	39.4	239.1	8527.0	234.9	7165.1	172.2	43.2	3525.5	64.3
12.00	0.5000	19.26	-171.1	21.1	128.1	-7016.3	400.2	41.9	254.0	8275.9	199.2	6269.5	166.9	48.7	4029.1	63.5
13.50	0.5000	24.37	-204.6	26.3	159.0	-6758.1	413.3	44.8	270.9	8012.8	171.0	5572.9	161.2	54.6	4532.8	63.3
15.00	0.5000	30.09	-232.5	31.3	188.4	-6479.3	426.0	48.0	289.2	7737.9	148.2	5015.6	155.2	60.9	5036.4	63.5
16.50	0.5000	36.41	-255.3	36.1	216.9	-6182.7	437.7	51.4	308.5	7452.2	129.2	4559.6	148.8	67.6	5540.1	64.0
18.00	0.5000	43.33	-273.4	40.9	244.6	-5871.3	447.7	55.0	328.5	7157.3	113.2	4179.6	142.2	74.6	6043.7	64.9
19.50	0.5000	50.85	-287.0	45.6	271.7	-5548.1	455.8	58.6	349.2	6855.0	99.4	3858.1	135.4	82.2	6547.3	65.9

VEH.		LAT. TURN		INNER SPROCKET		OUTER SPROCKET		STEER MOTOR		PROPULSION MOTOR		*SCRUB*TRANS	
SPEED	*ACCEL*	RADIUS	*APART*	PROP	RPM	TORQUE	*APART*	PROP	RPM	TORQUE	*HP	*TORQUE*	HP
(mph)	(g)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
21.00	*5000*	58.98	-296.3	50.3	298.4	-5216.0	461.6	62.5	370.3	6547.3	87.6	3582.6	128.4
22.50	*5000*	67.70	-301.5	55.0	324.6	-4878.0	465.2	66.4	391.8	6236.4	77.2	3343.7	121.3
24.00	*5000*	77.03	-302.9	59.7	350.6	-4536.8	466.5	70.4	413.6	5924.6	68.1	3134.7	114.2
25.50	*5000*	86.96	-300.6	64.5	376.3	-4195.1	465.6	74.6	435.6	5614.1	60.1	2950.3	107.1
27.00	*5000*	97.49	-295.0	69.2	401.9	-3855.6	462.6	78.8	457.8	5307.0	53.1	2786.4	100.0
28.50	*5000*	108.62	-286.4	74.0	427.2	-3520.5	457.7	83.2	480.2	5005.3	46.8	2639.8	93.0
30.00	*5000*	120.36	-275.0	78.9	452.4	-3192.0	451.0	87.6	502.8	4710.7	41.2	2507.8	86.2
31.50	*5000*	132.70	-261.1	83.8	477.5	-2872.0	442.7	92.2	525.5	4425.1	36.2	2388.4	79.6
33.00	*5000*	145.63	-245.1	88.7	502.5	-2562.1	433.2	96.8	548.3	4149.7	31.8	2279.8	73.2
34.50	*5000*	159.18	-227.3	93.8	527.4	-2263.8	422.6	101.6	571.1	3885.9	27.9	2180.7	67.1
36.00	*5000*	173.32	-208.0	98.9	552.2	-1978.3	411.2	106.4	594.1	3634.7	24.4	2089.8	61.3
37.50	*5000*	188.06	-187.4	104.1	576.9	-1706.5	399.2	111.4	617.2	3396.9	21.3	2006.2	55.7
39.00	*5000*	203.41	-166.0	109.4	601.5	-1449.0	386.8	116.5	640.3	3173.0	18.5	1929.1	50.4
40.50	*5000*	219.35	-143.8	114.8	626.1	-1206.4	374.6	121.6	663.4	2963.6	16.1	1857.6	45.5
42.00	*5000*	235.90	-121.3	120.3	650.7	-978.9	362.0	126.9	686.6	2768.7	13.9	1791.3	40.9
43.50	*5000*	253.06	-98.5	125.9	675.2	-766.5	349.9	132.3	709.9	2588.5	12.1	1729.5	36.6
45.00	*5000*	270.81	-75.8	131.6	699.6	-569.2	338.2	137.9	733.2	2422.7	10.4	1671.9	32.7

End

SPROCKET HORSEPOWER
BY: W.E. RODLER REV. DATE: 14 MAY 1985
L.M. FERNANDEZ

RUN DATE: 7-AUG-85:1

DATA INPUT:

GROSS VEHICLE WEIGHT, tons = 19.5 TREAD WIDTH, in. = 92.5 GRADE, % = 0.0
MAXIMUM VELOCITY, mph = 45.0 TRACK LENGTH, in. = 150.0 COEFFICIENT OF FRICTION = 0.70
ENGINE GROSS HP. = 500.0 TRACK PITCH, in. = 6.03 MAXIMUM ACCELERATION, gs = 0.50
LOSS ENGINE HP. = 60.0 NUMBER OF SPROCKET TEETH = 11
FRONTAL AREA, in. = 57.0 ROLLING RESISTANCE, lb per ton = 100.0 COEFFICIENT OF DRAG = 1.00

Efficiency data for Homopolar motor * CONCEPT 1: TWIN PROPULSION MOTORS
given by Gene Seider 20-MAY-85 *

RESULTS:

VEH	*LATERAL*	TURN	*INNER SPROCKET	*TORQUE	*APPART*	*PROP	*RPM	*OUTER SPROCKET	*TORQUE	*APPART*	*PROP	*RPM	*SCRUB	*TRANSFR*
SPEED	*ACCEL	*RADIUS*	*HP	*HP	*HP	*HP		*HP	*HP	*HP	*HP		*HP	
(mph)	(gs)	(ft)												
0.00*	0.000*	0.00*	165.50*	14.5*	-88.8*	-9783.3*	165.56*	14.5*	88.8*	9783.3*	151.0*	0.0		
1.50*	0.084*	1.78*	112.50*	10.0*	-61.0*	-9681.4*	200.54*	17.8*	108.79*	9681.4*	142.6*	40.1		
3.00*	0.070	8.62*	-18.21*	2.1*	12.6*	-7584.7*	146.84*	13.5*	82.91*	9301.3*	56.5*	76.8		
4.50*	0.149*	9.09*	-31.11*	3.5*	21.6*	-7558.6*	214.90*	19.9*	121.67*	9276.7*	80.2*	114.8		
6.00*	0.253*	9.50*	-45.53*	5.2*	31.7*	-7535.1*	280.73*	26.1*	159.31*	9255.2*	102.0*	152.7		
7.50*	0.340*	11.06*	-72.24*	8.4*	50.9*	-7449.7*	328.12*	30.8*	187.88*	9172.3*	108.4*	188.9		
9.00*	0.403*	13.45*	-105.50*	12.4*	75.7*	-7321.2*	363.26*	34.6*	210.88*	9047.1*	105.3*	223.3		
10.50*	0.453*	16.26*	-139.22*	16.8*	102.0*	-7172.1*	393.85*	38.3*	232.38*	8901.7*	99.8*	255.8		
12.00*	0.500*	19.26*	-171.14*	21.1*	128.1*	-7016.1*	423.13*	41.9*	253.98*	8750.1*	94.5*	286.7		
13.50*	0.500*	24.38*	-204.56*	26.3*	159.0*	-6757.8*	438.20*	44.8*	270.87*	8496.7*	81.2*	312.1		
15.00*	0.500*	30.10*	-232.48*	31.3*	188.5*	-6479.0*	452.73*	48.0*	289.15*	8223.3*	70.5*	334.2		
16.50*	0.500*	36.42*	-255.34*	36.1*	216.9*	-6182.4*	465.89*	51.4*	308.46*	7932.7*	61.5*	353.0		
18.00*	0.500*	43.34*	-273.43*	40.9*	244.6*	-5870.9*	477.14*	55.0*	328.52*	7628.0*	53.9*	368.3		
19.50*	0.500*	50.86*	-287.01*	45.6*	271.7*	-5547.7*	486.12*	58.6*	349.18*	7311.9*	47.4*	380.1		

SPROCKET HORSEPOWER RUN DATE: No. 7-AUG-85:1

VEH #	LATERAL #	TURN #	ACCEL #	RADIUS #	APPART #	INNER SPROCKET PROP #	RPM #	TORQUE #	APPART #	OUTER SPROCKET PROP #	RPM #	TORQUE #	SCRUB #	TRANSFER #
(mph)	(g)	(ft)	(ft)	(ft)	(ft)	HP		(ftlbs)	(ftlbs)	HP		(ftlbs)	HP	HP
21.00*	0.500*	58.99*	-796.29*	50.3*	298.4*	-5215.6*	492.65*	62.5*	370.29*	6987.6*	41.8*	388.4		
22.50*	0.500*	67.72*	-301.49*	55.0*	324.6*	-4877.5*	496.63*	66.4*	391.77*	6657.8*	36.9*	393.4		
24.00*	0.500*	77.05*	-302.83*	59.7*	350.6*	-4536.2*	498.08*	70.4*	413.56*	6325.6*	32.5*	395.1		
25.50*	0.500*	86.98*	-300.57*	64.5*	376.4*	-4196.5*	497.07*	74.6*	435.59*	5993.4*	28.7*	393.7		
27.00*	0.500*	97.51*	-294.97*	69.2*	401.9*	-3855.0*	493.72*	78.8*	457.82*	5663.9*	23.3*	389.9		
28.50*	0.500*	108.65*	-286.32*	74.0*	427.2*	-3519.9*	488.22*	83.2*	480.23*	5339.5*	22.3*	382.7		
30.00*	0.500*	120.38*	-274.92*	78.9*	452.4*	-3191.3*	480.78*	87.6*	502.79*	5022.2*	19.7*	373.5		
31.50*	0.500*	132.72*	-261.06*	83.8*	477.5*	-2871.3*	471.63*	92.2*	525.47*	4714.0*	17.3*	362.1		
33.00*	0.500*	145.66*	-245.06*	88.7*	502.5*	-2561.4*	461.04*	96.8*	548.26*	4416.6*	15.2*	349.0		
34.50*	0.500*	159.21*	-227.25*	93.8*	527.4*	-2263.2*	449.26*	101.6*	571.14*	4131.3*	13.3*	336.4		
36.00*	0.500*	173.35*	-207.91*	98.9*	552.2*	-1977.7*	436.57*	106.4*	594.11*	3859.3*	11.7*	318.5		
37.50*	0.500*	188.10*	-187.37*	104.1*	576.9*	-1705.9*	423.22*	111.4*	617.15*	3601.7*	10.2*	301.7		
39.00*	0.500*	203.45*	-165.89*	109.4*	601.5*	-1448.4*	409.47*	116.5*	640.26*	3358.9*	8.9*	284.2		
40.50*	0.486*	225.46*	-133.95*	114.9*	626.6*	-1122.7*	384.79*	121.5*	662.92*	3048.6*	7.2*	256.0		
42.00*	0.465*	253.66*	-95.32*	120.5*	651.9*	-767.9*	353.60*	126.7*	685.38*	2709.6*	5.5*	221.4		
43.50*	0.442*	286.56*	-55.11*	126.2*	677.2*	-427.4*	321.52*	132.0*	707.87*	2385.5*	4.1*	185.5		
45.00*	0.415*	326.13*	-13.66*	132.1*	702.5*	-102.1*	288.87*	137.3*	730.36*	2077.3*	2.9*	148.6		

End

SPROCKET HORSEPOWER
BY: W.E. RODLER REV. DATE: 14 MAY 1985
L.M. FERNANDEZ

RUN DATE: 15-AUG-85:115

DATA INPUT:

GROSS VEHICLE WEIGHT, tons = 40.0 TREAD WIDTH, in. = 109.8 GRADE, % = 0.0
MAXIMUM VELOCITY, mph = 45.0 TRACK LENGTH, in. = 193.1 COEFFICIENT OF FRICTION = 0.70
ENGINE GROSS HP = 1000.0 TRACK PITCH, in. = 7.63 MAXIMUM ACCELERATION, g = 0.50
LOSS ENGINE HP = 120.0 NUMBER OF SPROCKET TEETH = 11
FRONTAL AREA, in. = 68.3 ROLLING RESISTANCE, lb per ton = 100.0 COEFFICIENT OF DRAG = 1.00

Efficiency data for Westinghouse Induction motor * CONCEPT I: TWIN PROPULSION MOTORS
by Craig Joseph 10-MAY-85 *

RESULTS:

VEH	*LATERAL*	TURN	*ACCEL*	*RADIUS*	*APPARENT*	INNER	SPROCKET	*TORQUE*	*APPARENT*	OUTER	SPROCKET	*TORQUE*	*SCRUB*	*TRANSFER*
(mph)	(g)	(ft)	(ft)	(ft)	(ft)	HP	RPM	(ft-lbs)	HP	HP	RPM	(ft-lbs)	HP	HP
0.00	0.000	0.00	349.19	30.1	-71.2	-25773.3	349.31	30.2	71.18	25773.3	319.1	0.1		
1.50	0.069	2.17	235.50	20.6	-48.6	-25447.3	418.50	36.6	86.38	25447.3	298.4	83.5		
3.00	0.058	10.41	-36.58	4.1	9.7	-19794.3	303.90	27.9	65.83	24245.0	117.7	158.4		
4.50	0.123	11.01	-63.25	7.1	16.9	-19707.3	443.71	40.9	96.45	24160.9	166.2	236.6		
6.00	0.209	11.54	-93.05	10.6	24.9	-19631.3	578.74	53.5	126.19	24088.2	210.8	314.4		
7.50	0.286	13.16	-143.79	16.5	38.9	-19402.3	681.19	63.7	149.93	23862.5	228.6	388.9		
9.00	0.366	15.66	-207.94	24.4	57.3	-19054.3	758.19	72.0	169.31	23519.9	227.0	459.3		
10.50	0.399	18.46	-273.00	32.7	76.8	-18670.3	826.56	79.9	187.60	23141.0	220.5	526.2		
12.00	0.446	21.57	-336.72	41.3	96.9	-18251.3	888.32	87.5	205.27	22729.1	211.4	589.4		
13.50	0.493	24.72	-396.53	49.9	116.8	-17837.3	948.50	95.3	223.17	22321.7	203.4	649.8		
15.00	0.500	30.10	-458.07	60.0	140.3	-17148.3	978.23	101.6	237.41	22164.1	179.3	697.4		
16.50	0.500	36.42	-509.88	70.1	163.6	-16369.3	1000.94	108.0	251.88	20871.4	156.5	736.5		
18.00	0.500	43.34	-551.21	80.0	186.2	-15551.3	1020.29	114.7	267.08	20063.6	137.2	768.4		
19.50	0.500	50.84	-582.70	89.6	208.2	-14702.3	1035.42	121.8	282.86	19225.7	120.6	793.0		

SPROCKET HORSEPOWER RUN DATE: No. 15-AUG-85:115

VEH #	LATERAL * TURN *	INNER SPROCKET	OUTER SPROCKET	SCRUB * TRANSFR *								
SPEED * ACCEL	RADIUS * APPARNT *	PROP * RPM	TORQUE * APPARNT *	HP * HP								
(mph) * (gs)	(ft) * HP	HP	(ftlbs) * HP	(ftlbs) *								
21.00*	0.500*	58.99*	-604.90*	99.2*	229.7*	-13830.*	1045.80*	129.1*	18299.07*	18365.6*	106.3*	810.4
22.50*	0.500*	67.72*	-618.33*	108.6*	250.9*	-12943.*	1051.19*	136.7*	315.65*	17490.9*	93.8*	820.7
24.00*	0.500*	77.05*	-623.52*	118.0*	271.8*	-12048.*	1051.53*	144.4*	332.51*	16609.2*	82.8*	824.3
25.50*	0.500*	86.98*	-621.03*	127.4*	292.5*	-11152.*	1046.92*	152.3*	349.61*	15727.5*	73.1*	821.5
27.00*	0.500*	97.51*	-611.45*	136.8*	313.0*	-10261.*	1037.59*	160.4*	366.91*	14852.6*	64.5*	812.7
28.50*	0.500*	108.65*	-595.40*	146.2*	333.3*	-9383.*	1023.90*	168.6*	384.37*	13990.6*	56.9*	798.4
30.00*	0.500*	120.38*	-573.52*	155.6*	353.4*	-8523.*	1006.25*	177.0*	401.98*	13147.3*	50.1*	779.2
31.50*	0.500*	132.72*	-546.48*	165.1*	373.5*	-7685.*	985.12*	185.5*	419.71*	12327.5*	44.0*	755.6
33.00*	0.500*	145.66*	-514.94*	174.6*	393.4*	-6875.*	961.03*	194.2*	437.54*	11535.7*	38.7*	728.2
34.50*	0.500*	159.21*	-479.57*	184.2*	413.3*	-6095.*	934.49*	203.0*	455.47*	10775.8*	33.9*	697.6
36.00*	0.500*	173.35*	-441.03*	193.8*	433.0*	-5349.*	906.07*	211.9*	473.48*	10050.7*	29.7*	664.5
37.50*	0.500*	188.10*	-399.96*	203.5*	452.7*	-4640.*	876.29*	221.0*	491.55*	9362.9*	25.9*	629.4
39.00*	0.500*	203.45*	-356.96*	213.4*	472.3*	-3969.*	845.67*	230.2*	509.69*	8714.2*	22.5*	592.9
40.50*	0.500*	219.40*	-312.62*	223.3*	491.9*	-3338.*	814.72*	239.6*	527.88*	8105.9*	19.6*	555.5
42.00*	0.500*	235.95*	-267.45*	233.3*	511.4*	-2746.*	783.89*	249.2*	546.13*	7538.7*	17.0*	517.8
43.50*	0.500*	253.11*	-221.94*	243.5*	530.9*	-2195.*	753.60*	258.8*	564.41*	7012.6*	14.7*	480.1
45.00*	0.500*	270.86*	-176.52*	253.7*	550.4*	-1684.*	724.24*	268.7*	582.74*	6527.4*	12.7*	442.9

End

 SPROCKET HORSEPOWER
 BY: M.E. RUDLER REV. DATE: 13 JUNE 1985
 R.E. LEWIS

 RUN DATE: 15-AUG-85:116

DATA INPUT:

 GROSS VEHICLE WEIGHT, tons = 40.0 TREAD WIDTH, in. = 109.8 GRADE, % = 0.0
 MAXIMUM VELOCITY, mph = 45.0 TRACK LENGTH, in. = 183.1 COEFFICIENT OF FRICTION = 0.70
 ENGINE GROSS HP. = 1000.0 TRACK PITCH, in. = 7.63 MAXIMUM ACCELERATION, g = 0.50
 LOSS ENGINE HP. = 120.0 NUMBER OF SPROCKET TEETH = 11 COEFFICIENT OF DRAG = 1.00
 FRONTAL AREA, ft² = 68.3 ROLLING RESISTANCE, lb per ton = 100.0 PROPULSION MOTOR EFF. % = 94.
 STEER MOTOR EFF. % = 92. STEER SYS. GEAR RATIO = 99:1 PROP. SYS. GEAR RATIO = 21:1

 Efficiency data for Westinghouse Induction motor * CONFIGURATION II
 by Craig Joseph 10-MAY-85 PROPULSION/STEER MOTOR SET-UP

RESULTS:

VEH.	* LAT.	* TURN	* INNER SPROCKET	* RPM	* TORQUE	* HP	* PROPULSION MOTOR	* RPM	* TORQUE	* HP	* SCRUB/TRANS							
SPEED	* ACCELERATION	* RADIUS	* APART	* PROP	* HP	* (lbft)	* HP	* RPM	* TORQUE	* HP	* HP							
(mph)	(g)	(ft)	* HP	* HP	* (lbft)	* (lbft)	* (lbft)	* (lbft)	* (lbft)	* (lbft)	* (lbft)							
0.00	*.0000*	0.00*	288.1*	24.9*	-58.7*	-25774.*	208.2*	24.9*	58.7*	25773.*	626.4*	5848.6*	562.5*	0.0*	0.3*	0.0*	263.3*	0.1
1.50	*.0720*	2.09*	247.5*	21.6*	-51.0*	-25459.*	423.9*	37.6*	88.8*	25064.*	731.2*	6965.5*	551.4*	-1.5*	398.3*	-19.9*	309.4*	83.5
3.00	*.1470*	4.09*	161.1*	14.2*	-33.6*	-25161.*	509.8*	46.3*	109.2*	24527.*	734.1*	7110.2*	542.3*	-4.9*	796.6*	-32.0*	311.7*	164.9
4.50	*.2250*	6.02*	76.7*	6.9*	-16.2*	-24880.*	593.9*	54.9*	129.5*	24087.*	738.2*	7255.2*	534.4*	-9.1*	1194.9*	-40.0*	314.2*	244.4
6.00	*.3040*	7.92*	-6.6*	0.7*	1.7*	-20149.*	674.0*	63.4*	149.4*	23700.*	669.8*	7351.9*	478.5*	54.3*	1593.2*	179.1*	314.5*	321.8
7.50	*.3790*	9.92*	-78.7*	8.8*	20.8*	-19859.*	746.4*	71.4*	168.0*	23327.*	658.0*	7332.5*	471.3*	66.3*	1991.4*	174.9*	309.6*	397.1
9.00	*.4560*	11.93*	-148.4*	16.9*	39.8*	-19573.*	817.3*	79.4*	186.8*	22980.*	647.2*	7319.5*	464.4*	78.2*	2389.7*	171.9*	305.1*	470.4
10.50	*.5000*	14.74*	-229.4*	26.7*	62.8*	-19178.*	864.5*	85.8*	201.6*	22525.*	598.7*	6909.6*	455.1*	89.6*	2788.0*	168.9*	282.8*	539.0
12.00	*.5000*	19.26*	-319.4*	38.5*	90.4*	-18560.*	881.1*	90.3*	221.8*	21851.*	507.7*	6045.9*	441.0*	100.7*	3186.3*	166.0*	240.4*	598.3
13.50	*.5000*	24.37*	-395.0*	49.5*	116.0*	-17882.*	901.5*	95.6*	223.9*	21145.*	435.8*	5374.1*	425.9*	112.3*	3584.6*	164.6*	206.7*	651.3
15.00	*.5000*	30.09*	-458.1*	60.0*	140.3*	-17149.*	922.5*	101.6*	227.4*	20408.*	377.5*	4836.7*	409.9*	124.7*	3982.9*	164.4*	179.3*	697.4
16.50	*.5000*	36.41*	-509.9*	70.1*	163.6*	-16370.*	942.1*	108.0*	231.9*	19644.*	329.0*	4397.0*	393.0*	137.8*	4381.2*	165.1*	156.5*	736.5
18.00	*.5000*	43.33*	-551.2*	80.0*	186.2*	-15552.*	958.9*	114.7*	267.1*	18956.*	288.2*	4030.6*	375.5*	151.7*	4779.5*	166.7*	137.2*	768.4
19.50	*.5000*	50.85*	-582.7*	89.6*	208.2*	-14704.*	972.1*	121.8*	282.9*	18049.*	253.2*	3720.5*	357.4*	166.4*	5177.8*	168.8*	120.7*	793.0

SPROCKET HORSEPOWER RUN DATE: No. 15-AUG-85:116

VEH. SPEED (mph)	*LAT*	*TURN*	*INNER SPROCKET *APART* *RPM*	*TORQUE *(lbft)* *HP*	*OUTER SPROCKET *APART* *RPM*	*TORQUE *(lbft)* *HP*	*STEER MOTOR *RPM*	*TORQUE *(lbft)* *HP*	*PROPULSION MOTOR *RPM*	*TORQUE *(lbft)* *HP*	*SCRUB*TRANS *HP*								
21.00	*	*	58.98	-605.0	99.2	229.7	-13832.0	981.1	1129.1	299.1	17229.0	223.0	3654.8	339.0	181.9	5576.1	171.3	106.3	810.5
22.50	*	*	67.70	-618.4	108.6	250.9	-12945.0	985.6	1136.7	315.7	16400.0	196.6	3224.5	320.2	198.3	5974.3	174.3	93.8	820.8
24.00	*	*	77.03	-623.6	118.0	271.8	-12049.0	985.7	1144.4	332.5	15569.0	173.5	3022.9	301.4	215.4	6372.6	177.5	82.8	824.4
25.50	*	*	86.96	-621.1	127.4	292.5	-11153.0	981.3	1152.3	349.6	14742.0	153.1	2845.1	282.6	233.4	6770.9	181.0	73.1	821.6
27.00	*	*	97.49	-611.6	136.8	313.0	-10263.0	972.7	1160.4	366.9	13924.0	135.0	2687.0	264.0	252.0	7169.2	184.6	64.5	812.9
28.50	*	*	108.62	-595.5	146.2	333.3	-9385.0	960.2	1168.6	384.4	13120.0	119.0	2545.6	245.6	271.4	7567.5	188.4	56.9	798.6
30.00	*	*	120.36	-573.6	155.6	353.4	-8525.0	944.1	1177.0	402.0	12335.0	104.8	2418.3	227.6	291.5	7965.8	192.2	50.1	779.3
31.50	*	*	132.70	-546.6	165.1	373.5	-7687.0	924.8	1185.5	419.7	11573.0	92.2	2303.2	210.2	312.2	8364.1	196.0	44.1	755.7
33.00	*	*	144.63	-515.1	174.6	393.4	-6877.0	902.9	1194.2	437.5	10838.0	80.9	2198.5	193.3	333.4	8762.4	199.0	38.7	728.3
34.50	*	*	159.18	-479.7	184.1	413.2	-6097.0	878.8	1203.0	455.5	10134.0	70.9	2102.9	177.1	355.2	9160.7	203.6	33.9	697.8
36.00	*	*	173.32	-441.2	193.8	433.0	-5351.0	853.1	1211.9	473.5	9463.0	62.0	2015.3	161.7	377.5	9559.0	207.4	29.7	664.7
37.50	*	*	188.06	-400.1	203.5	452.7	-4642.0	826.1	1221.0	491.6	8827.0	54.1	1934.7	147.0	400.2	9957.2	211.1	25.9	629.6
39.00	*	*	203.41	-357.1	213.4	472.3	-3971.0	798.4	1230.2	509.7	8227.0	47.2	1860.3	133.1	423.3	10355.5	214.7	22.6	593.1
40.50	*	*	219.35	-312.8	223.3	491.9	-3339.0	770.4	1239.6	527.9	7665.0	41.0	1791.4	120.1	446.8	10753.8	218.2	19.6	555.7
42.00	*	*	235.90	-267.6	233.3	511.4	-2748.0	742.6	1249.2	546.1	7142.0	35.5	1727.4	107.9	470.6	11152.1	221.6	17.0	517.9
43.50	*	*	253.06	-222.1	243.5	530.9	-2197.0	715.4	1258.8	564.4	6657.0	30.7	1667.8	96.6	494.7	11550.4	225.0	14.7	480.3
45.00	*	*	270.81	-176.7	253.7	550.4	-1686.0	689.0	1268.7	582.7	6209.0	26.4	1612.2	86.2	519.1	11948.7	228.2	12.7	443.1

*****End*****

RUN DATE: 15-AUG-85:114

DATA INPUT:

GROSS VEHICLE WEIGHT, tons = 40.0	TREAD WIDTH, in. = 109.8	GRADE, % = 0.0
MAXIMUM VELOCITY, mph = 45.0	TRACK LENGTH, in. = 183.1	COEFFICIENT OF FRICTION = 0.70
ENGINE GROSS HP. = 1000.0	TRACK PITCH, in. = 7.63	MAXIMUM ACCELERATION, gs = 0.50
LOSS ENGINE HP. = 120.0	NUMBER OF SPROCKET TEETH = 11	
ENGINE AREA, in. = 68.3	ROLLING RESISTANCE/lb per ton = 100.0	COEFFICIENT OF DRAG = 1.00

Efficiency data for Homopolar motor
given by Gene Seider 20-MAY-85

* CONCEPT 1: TWIN PROPULSION MOTORS

RESULTS:

VEH	*LATERAL*	*TURN*	*INNER*	*SPROCKET*	*OUTER*	*SPROCKET*	*TORQUE*	*SCRUB*	*TRANSFR*		
SPEED	*ACCEL	*RADIUS*	*APPART*	*RPM	*PROP	*RPM	*HP	*HP			
(mph)	(g)	(ft)	(ft)	(ft/lbs)	(ft/lbs)	(ft/lbs)	(ft/lbs)	(ft/lbs)			
0.00*	0.000*	0.000*	330.32*	28.5*	-67.3*	-25773.*	330.44*	28.5*	67.34*25773.3*	301.9*	0.1
1.50*	0.066*	2.28*	219.38*	19.2*	-45.3*	-25431.*	402.26*	35.2*	83.-08*25430.6*	283.6*	83.4
3.00*	0.057*	10.63*	-38.72*	4.4*	10.3*	-19762.*	300.83*	27.7*	65.-25*24213.6*	115.0*	158.1
4.50*	0.120*	11.23*	-66.17*	7.5*	17.7*	-19675.*	439.42*	40.6*	95.-65*24128.7*	162.6*	236.3
6.00*	0.205*	11.75*	-96.21*	10.9*	25.8*	-19603.*	574.01*	53.-2*	125.31*24059.3*	206.9*	314.0
7.50*	0.271*	13.89*	-153.69*	17.8*	41.8*	-19301.*	665.20*	62.4*	147.03*23761.6*	215.7*	387.1
9.00*	0.321*	16.85*	-220.40*	26.0*	61.3*	-18892.*	735.34*	70.3*	165.35*23357.1*	209.3*	455.7
10.50*	0.364*	20.27*	-286.78*	34.8*	81.7*	-18428.*	796.38*	77.7*	182.66*22898.8*	198.5*	520.1
12.00*	0.404*	23.83*	-348.80*	43.5*	102.0*	-17956.*	854.86*	85.3*	200.14*22433.3*	188.6*	580.9
13.50*	0.440*	27.71*	-407.10*	52.3*	122.5*	-17453.*	908.17*	92.8*	217.43*21937.8*	178.0*	637.4
15.00*	0.468*	32.17*	-461.26*	61.4*	143.4*	-16890.*	953.83*	100.2*	234.27*21383.6*	165.5*	688.1
16.50*	0.492*	37.01*	-509.86*	70.4*	164.3*	-16297.*	994.70*	107.7*	251.17*20800.0*	153.4*	733.7
18.00*	0.500*	43.34*	-551.21*	80.0*	186.2*	-15551.*	1020.29*	114.7*	267.08*20063.6*	137.2*	768.4
19.50*	0.500*	50.96*	-582.70*	89.6*	208.2*	-14702.*	1035.42*	121.8*	282.86*19225.7*	120.6*	793.0

HORSEPOWER

PU3

B.2.D Gear Speeds And Loads at Maximum Turn Conditions

The following tables provide the torque and speed data for all gears during maximum turn conditions. These tables are divided into the same three divisions as the previous tables. The Title Heading and the inputs are the same as the previous section. The data format facilitates analysis by placing speeds and torques of each component in adjacent positions.

The first row of the results section lists the components by name or by identification letter shown on the gear configuration diagrams. The next segment defines the data arrangement; typically RPM above a dotted line and torque in pound-feet immediately below. The data output is immediately below, with horizontal dotted lines for each 1.5 MPH increment, and corresponding speeds and torques above and below the dotted line.

B-54

RUN DATE: No. 20-AUG-85:5

[illegible]

B-60

BY: RICK LEWIS; REVISION: 16-JUL-85
 RUN DATE: 20-AUG-85;112

GROSS VEHICLE WEIGHT, tons =	40.0	TREAD WIDTH, in. =	109.8	GRADE, % =	0.0
MAXIMUM VELOCITY, mph =	45.0	TRACK LENGTH, in. =	183.1	COEFFICIENT OF FRICTION =	0.70
ENGINE GROSS HP. =	1000.0	TRACK PITCH, in. =	7.63	MAXIMUM ACCELERATION, g's =	0.50
LOSS ENGINE HP. =	120.0	NUMBER OF SPROCKET TEETH =	11	COEFFICIENT OF DRAG =	1.00
FRONTAL AREA, ft ² =	68.3	ROLLING RESISTANCE, lb per ton =	100.0		

ALTERNATIVE I TWIN DRIVE MOTOR SET-UP

MPH	MAX VEH	INNER SPROK	OUTER SPROK	INNER MOTOR=A	OUTER MOTOR=A	INNER B	OUTER B	INNER C & D	OUTER C & D	INNER E	OUTER E	INNER F	OUTER F
RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM	RPM
		TORQUE	TORQUE	TORQUE	TORQUE	TORQUE	TORQUE	TORQUE	TORQUE	TORQUE	TORQUE	TORQUE	TORQUE
		ftxlbs	ftxlbs	ftxlbs	ftxlbs	ftxlbs	ftxlbs	ftxlbs	ftxlbs	ftxlbs	ftxlbs	ftxlbs	ftxlbs
71.0	-71.0	25777.1	1759.0	1758.0	457.0	-457.0	457.0	-126.0	125.0	329.0	-329.0	-71.0	71.0
-25777.1		1306.1	-1305.1	-4349.1	4349.1	-14616.1	14616.1	1395.1	-1395.1	-22829.1	22826.1		
-49.0		86.0	2134.0	1201.0	312.0	-152.0	86.0	399.0	-224.0	-49.0	86.0		
-25450.1		1289.1	-1289.1	-4294.1	4294.1	-14431.1	14431.1	1377.1	-1377.1	-22540.1	22538.1		
10.0		66.0	1627.0	240.0	-62.0	-116.0	-17.0	304.0	45.0	10.0	66.0		
-19796.1		1228.1	-1002.1	-4091.1	3340.1	-13749.1	11225.1	1312.1	-1071.1	-17024.1	21982.1		
17.0		96.0	2383.0	417.0	-108.0	-170.0	-30.0	446.0	78.0	17.0	96.0		
-19710.1		1224.1	-998.1	-4077.1	3325.1	-13701.1	11176.1	1308.1	-1067.1	-16947.1	21908.1		
25.0		126.0	3118.0	615.0	-160.0	-223.0	-44.0	583.0	115.0	25.0	126.0		
-19634.1		1220.1	-994.1	-4064.1	3313.1	-13660.1	11133.1	1304.1	-1063.1	-16880.1	21844.1		
39.0		150.0	3705.0	962.0	-250.0	-264.0	-69.0	692.0	180.0	39.0	150.0		
-19405.1		1209.1	-982.1	-4026.1	3274.1	-13532.1	11003.1	1292.1	-1050.1	-16676.1	21644.1		
57.0		169.0	4184.0	1416.0	-368.0	-1086.0	-101.0	782.0	265.0	57.0	169.0		
-19057.1		1191.1	-965.1	-3969.1	3215.1	-13338.1	10806.1	1273.1	-1031.1	-16367.1	21341.1		

GEAR LOADS AT MAXIMUM TURN CONDITION

RUN DATE: NO. 20-AUG-85:112

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[illegible]

58-85

INPUT DATA:

GROSS VEHICLE WEIGHT, tons =	40.0	TREAD WIDTH, in. =	109.8	GRADE, % =	0.0
MAXIMUM VELOCITY, mph =	45.0	TRACK LENGTH, in. =	103.1	COEFFICIENT OF FRICTION =	0.70
ENGINE GROSS HP. =	1000.0	TRACK PITCH, in. =	7.63	MAXIMUM ACCELERATION, g's =	0.50
LOSS ENGINE HP. =	120.0	NUMBER OF SPROCKET TEETH =	11	COEFFICIENT OF DRAG =	1.00
FRONTAL AREA, ft. ² =	68.3	ROLLING RESISTANCE, lb per ton =	100.0	PUSHPROPEL MOTOR EFF, % =	94.
STEER MOTOR EFF, % =	92.	ROLLING SYS. GEAR RATIO =	99:1	PROP. SYS. GEAR RATIO =	21:1

Efficiency data for Westinghouse induction motor #
by Craig Joseph 10-MAY-85

[illegible][illegible]

B-67

GEAR LOADS AT MAXIMUM TURN CONDITION RUN DATE: No. 15-AUG-85:113

MAX	INNER	OUTER	PROG	OUTER	INNER	OUTER	INNER	OUTER	STEER	H	J	K	L				
VEH	*SPROK	*MOTOR	*B	*C	*D	*E	*F	*F	*MOTOR	*	*	*	*				
MPH	*RPM	*RPM	*RPM	*RPM	*RPM	*RPM	*RPM	*RPM	*RPM	*RPM	*RPM	*RPM	*RPM				
28.5#	333.0	384.0	7568.0	4236.0	5014.0	149.0	-149.0	1538.0	1333.0	-769.0	0.0	0.0	2546.0	-778.0	0.0	483.0	-126.0
	I -9384	I 13119	I 188	I 483	I 5852	I 5852	I 3279	I 2346	I 1093	I 782	I -9839	I 7038	I 245	I -200	I -1049	I 1294	I 4956
30.0#	353.0	402.0	7966.0	4498.0	5237.0	142.0	-142.0	1608.0	1414.0	-804.0	0.0	0.0	2418.0	-739.0	0.0	459.0	-120.0
	I -8524	I 12334	I 192	I 440	I -598	I 5424	I -5424	I 3083	I -2131	I -1027	I 710	I -9250	I 6393	I 227	I -186	I -972	I 1200
31.5#	373.0	420.0	8364.0	4759.0	5463.0	135.0	-135.0	1679.0	1494.0	-839.0	0.0	0.0	2303.0	-704.0	0.0	437.0	-114.0
	I -7686	I 11572	I 196	I 399	I -559	I 5008	I -5008	I 2893	I -1921	I -364	I 640	I -8679	I 5765	I 210	I -171	I -898	I 1108
33.0#	393.0	438.0	8762.0	5019.0	5691.0	129.0	-129.0	1750.0	1574.0	-875.0	0.0	0.0	2199.0	-672.0	0.0	417.0	-109.0
	I -6876	I 10838	I 199	I 359	I -522	I 4607	I -4607	I 2709	I -1719	I -903	I 573	I -8128	I 5157	I 193	I -158	I -825	I 1019
34.5#	413.0	455.0	9161.0	5277.0	5919.0	123.0	-123.0	1822.0	1653.0	-911.0	0.0	0.0	2103.0	-643.0	0.0	399.0	-104.0
	I -6096	I 10133	I 203	I 320	I -487	I 4221	I -4221	I 2533	I -1524	I -844	I 508	I -7600	I 4572	I 177	I -144	I -756	I 933
36.0#	433.0	473.0	9559.0	5534.0	6149.0	118.0	-118.0	1894.0	1732.0	-947.0	0.0	0.0	2015.0	-616.0	0.0	382.0	-100.0
	I -5351	I 9462	I 207	I 284	I -453	I 3852	I -3852	I 2365	I -1337	I -788	I 445	I -7096	I 4013	I 161	I -132	I -690	I 852
37.5#	453.0	492.0	9957.0	5789.0	6381.0	113.0	-113.0	1966.0	1811.0	-983.0	0.0	0.0	1935.0	-591.0	0.0	367.0	-96.0
	I -4641	I 8826	I 211	I 249	I -421	I 3502	I -3502	I 2206	I -1160	I -735	I 386	I -6619	I 3481	I 146	I -120	I -627	I 774
39.0#	472.0	510.0	10356.0	6044.0	6613.0	109.0	-109.0	2039.0	1889.0	-1019.0	0.0	0.0	1860.0	-568.0	0.0	353.0	-92.0
	I -3970	I 8227	I 214	I 215	I -391	I 3172	I -3172	I 2056	I -992	I -685	I 330	I -6170	I 2978	I 133	I -108	I -568	I 701
40.5#	492.0	528.0	10754.0	6298.0	6845.0	105.0	-105.0	2112.0	1968.0	-1056.0	0.0	0.0	1791.0	-547.0	0.0	340.0	-89.0
	I -3339	I 7665	I 210	I 184	I -363	I 2862	I -2862	I 1916	I -834	I -638	I 278	I -5748	I 2504	I 120	I -98	I -513	I 633
42.0#	511.0	547.0	11152.0	6551.0	7079.0	101.0	-101.0	2185.0	2046.0	-1092.0	0.0	0.0	1727.0	-528.0	0.0	328.0	-86.0
	I -2748	I 7161	I 221	I 155	I -336	I 2572	I -2572	I 1785	I -687	I -595	I 229	I -5356	I 2061	I 107	I -88	I -461	I 569
43.5#	531.0	564.0	11550.0	6804.0	7313.0	98.0	-98.0	2258.0	2124.0	-1129.0	0.0	0.0	1668.0	-510.0	0.0	316.0	-83.0
	I -2196	I 6656	I 224	I 128	I -312	I 2302	I -2302	I 1664	I -549	I -554	I 183	I -4992	I 1647	I 96	I -79	I -412	I 509
45.0#	550.0	583.0	11949.0	7056.0	7548.0	94.0	-94.0	2331.0	2201.0	-1165.0	0.0	0.0	1612.0	-493.0	0.0	306.0	-80.0
	I -1685	I 6209	I 228	I 103	I -289	I 2053	I -2053	I 1552	I -421	I -517	I 140	I -4656	I 1264	I 86	I -70	I -368	I 454

End

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*****  
GEAR LOADS AT MAXIMUM TURN CONDITION  
  
BY: RICK LEWIS:  
REVISION: 16-JUL-85  
RUN DATE: 15-AUG-85:111  
*****
```

GEAR LOADS AT MAXIMUM TURN CONDITION

INPUT DATA:

GROSS VEHICLE WEIGHT, tons = 40.0	TREAD WIDTH, in. = 109.8	GRADE, % = 0.0
MAXIMUM VELOCITY, mph = 45.0	TRACK LENGTH, in. = 183.1	COEFFICIENT OF FRICTION = 0.70
ENGINE GROSS HP. = 1000.0	TRACK PITCH, in. = 7.63	MAXIMUM ACCELERATION, g's = 0.50
LOSS ENGINE HP. = 120.0	NUMBER OF SPROCKET TEETH = 11	COEFFICIENT OF DRAG = 1.00
FRONTAL AREA, ft ² = 68.3	ROLLING RESISTANCE, lb per ton = 100.0	

[illegible]

Efficiency data for Homopolar motor
by Gene Siedler 20-MAY-85

[illegible]

0.0#	-67.#	67.#	-1410.#	1411.#	1611#	-1612#	-513.#	513.#	675.#	-675.#	0.#	0.#	-186.#	186.#	244.#	-245.#	0.#	0.#
	-1-257731257731	1230.-1-1230.-1	359.-1	-359.-1-3383.-1	3383.-1	7714.-1-7714.-1	5955.-1-5955.-1	9338.-1	9398.-142582.-1	42582116435.-1-164351.-1								
1.5#	-45.#	83.#	-949.#	1740.#	1084#	-1988#	-345.#	633.#	454.#	-833.#	0.#	0.#	-125.#	229.#	165.#	-302.#	0.#	0.#
	-1-254301254301	1214.-1-1214.-1	354.-1	-354.-1-3338.-1	3338.-1	7612.-1-7612.-1	5876.-1-5876.-1	9214.-1	9214.-142016.-1	42015116217.-1-162161.-1								
3.0#	10.#	65.#	216.#	1367.#	-246#	-1562#	78.#	497.#	-103.#	-654.#	0.#	0.#	28.#	180.#	-37.#	-237.#	0.#	0.#
	-1-197621242131	1156.-1	-943.-1	275.-1	-337.-1-2594.-1	3179.-1	5915.-1-7247.-1	4566.-1-5594.-1	7160.-1	8773.-132651.-1	40005112602.-1-154401.-1							
4.5#	18.#	96.#	370.#	2004.#	-422#	-2289#	135.#	729.#	-177.#	-959.#	0.#	0.#	49.#	264.#	-64.#	-347.#	0.#	0.#
	-1-196751241281	1152.-1	-939.-1	274.-1	-336.-1-2583.-1	3167.-1	5889.-1-7222.-1	4546.-1-5575.-1	7129.-1	8742.-132507.-1	39864112546.-1-153861.-1							
6.0#	26.#	125.#	540.#	2625.#	-617#	-2999#	196.#	955.#	-258.#	-1256.#	0.#	0.#	71.#	346.#	-94.#	-455.#	0.#	0.#
	-1-196021240591	1149.-1	-936.-1	273.-1	-335.-1-2573.-1	3158.-1	5867.-1-7201.-1	4529.-1-5559.-1	7102.-1	8717.-132387.-1	39750112500.-1-153421.-1							
7.5#	42.#	147.#	876.#	3080.#	-1001#	-3520#	319.#	1120.#	-419.#	-1474.#	0.#	0.#	115.#	406.#	-152.#	-534.#	0.#	0.#
	-1-193011237611	1134.-1	-921.-1	269.-1	-331.-1-2534.-1	3119.-1	5777.-1-7112.-1	4459.-1-5690.-1	6993.-1	8609.-131889.-1	39258112308.-1-151521.-1							
9.0#	61.#	165.#	1284.#	3464.#	-1466#	-3958#	467.#	1260.#	-614.#	-1657.#	0.#	0.#	169.#	456.#	-223.#	-600.#	0.#	0.#
	-1-186911233571	1115.-1	-902.-1	263.-1	-325.-1-2480.-1	3066.-1	5654.-1-6991.-1	4365.-1-5397.-1	6845.-1	8463.-131212.-1	38589112047.-1-148991.-1							

B-70

B.2.E Maximum Power Gear Loads And Speeds

These tables are identical to those of Appendix Section B.2.D except that they are for the full range of specified speed vs tractive effort. Refer to Section B.2.D if a detailed explanation of the data sheets is needed.

GEAR LOADS AT MAXIMUM TRACTIVE EFFORT CONDITION

RUN DATE: NO. 20-AUG-85:8

VEH #	SPROK #	RPM #	TORQUE #	FTXlbs #	INNER #	TORQUE #	FTXlbs #	OUTER #	TORQUE #	FTXlbs #	INNER #	TORQUE #	FTXlbs #	OUTER #	TORQUE #	FTXlbs #	INNER #	TORQUE #	FTXlbs #	OUTER #	TORQUE #	FTXlbs #	INNER #	TORQUE #	FTXlbs #	OUTER #	TORQUE #	FTXlbs #
MPH #	SPROK #	RPM #	TORQUE #	FTXlbs #	INNER #	TORQUE #	FTXlbs #	OUTER #	TORQUE #	FTXlbs #	INNER #	TORQUE #	FTXlbs #	OUTER #	TORQUE #	FTXlbs #	INNER #	TORQUE #	FTXlbs #	OUTER #	TORQUE #	FTXlbs #	INNER #	TORQUE #	FTXlbs #	OUTER #	TORQUE #	FTXlbs #
10.5#	167.#	167.#	3498.#	269.1	3498.#	269.1	269.1	3498.#	269.1	269.1	3498.#	269.1	269.1	3498.#	269.1	269.1	3498.#	269.1	269.1	3498.#	269.1	269.1	3498.#	269.1	269.1	3498.#	269.1	269.1
12.0#	191.#	191.#	3998.#	237.1	3998.#	237.1	237.1	3998.#	237.1	237.1	3998.#	237.1	237.1	3998.#	237.1	237.1	3998.#	237.1	237.1	3998.#	237.1	237.1	3998.#	237.1	237.1	3998.#	237.1	237.1
13.5#	215.#	215.#	4498.#	212.1	4498.#	212.1	212.1	4498.#	212.1	212.1	4498.#	212.1	212.1	4498.#	212.1	212.1	4498.#	212.1	212.1	4498.#	212.1	212.1	4498.#	212.1	212.1	4498.#	212.1	212.1
15.0#	239.#	239.#	4997.#	192.1	4997.#	192.1	192.1	4997.#	192.1	192.1	4997.#	192.1	192.1	4997.#	192.1	192.1	4997.#	192.1	192.1	4997.#	192.1	192.1	4997.#	192.1	192.1	4997.#	192.1	192.1
16.5#	263.#	263.#	5497.#	175.1	5497.#	175.1	175.1	5497.#	175.1	175.1	5497.#	175.1	175.1	5497.#	175.1	175.1	5497.#	175.1	175.1	5497.#	175.1	175.1	5497.#	175.1	175.1	5497.#	175.1	175.1
21.0#	334.#	334.#	6996.#	138.1	6996.#	138.1	138.1	6996.#	138.1	138.1	6996.#	138.1	138.1	6996.#	138.1	138.1	6996.#	138.1	138.1	6996.#	138.1	138.1	6996.#	138.1	138.1	6996.#	138.1	138.1
22.5#	358.#	358.#	7496.#	129.1	7496.#	129.1	129.1	7496.#	129.1	129.1	7496.#	129.1	129.1	7496.#	129.1	129.1	7496.#	129.1	129.1	7496.#	129.1	129.1	7496.#	129.1	129.1	7496.#	129.1	129.1
24.0#	382.#	382.#	7996.#	121.1	7996.#	121.1	121.1	7996.#	121.1	121.1	7996.#	121.1	121.1	7996.#	121.1	121.1	7996.#	121.1	121.1	7996.#	121.1	121.1	7996.#	121.1	121.1	7996.#	121.1	121.1
25.5#	406.#	406.#	8496.#	114.1	8496.#	114.1	114.1	8496.#	114.1	114.1	8496.#	114.1	114.1	8496.#	114.1	114.1	8496.#	114.1	114.1	8496.#	114.1	114.1	8496.#	114.1	114.1	8496.#	114.1	114.1
27.0#	430.#	430.#	8995.#	107.1	8995.#	107.1	107.1	8995.#	107.1	107.1	8995.#	107.1	107.1	8995.#	107.1	107.1	8995.#	107.1	107.1	8995.#	107.1	107.1	8995.#	107.1	107.1	8995.#	107.1	107.1
	243.1	243.1	2121.1	107.1	2121.1	107.1	107.1	2121.1	107.1	107.1	2121.1	107.1	107.1	2121.1	107.1	107.1	2121.1	107.1	107.1	2121.1	107.1	107.1	2121.1	107.1	107.1	2121.1	107.1	107.1

GEAR LOADS AT MAXIMUM TRACTIVE EFFORT CONDITION

RUN DATE: No. 20-AUG-85:8

MAX # VEH #	INNER # SPROK #	OUTER # SPROK #	INNER # MOTOR=A #	OUTER # MOTOR=A #	INNER # B #	OUTER # B #	INNER # C & D #	OUTER # C & D #	INNER # E #	OUTER # E #	INNER # F #	OUTER # F #
MPH #	RPM #	TORQUE # ftlbs	RPM #	TORQUE # ftlbs	RPM #	TORQUE # ftlbs	RPM #	TORQUE # ftlbs	RPM #	TORQUE # ftlbs	RPM #	TORQUE # ftlbs
28.5*	454.*	454.*	9495.*	9495.*	-2912.*	-2912.*	-800.*	-800.*	2096.*	2096.*	454.*	454.*
	2009.1	2009.1	102.1	102.1	-339.1	-339.1	-1139.1	-1139.1	109.1	109.1	230.1	230.1
30.0*	478.*	478.*	9995.*	9995.*	-3065.*	-3065.*	-842.*	-842.*	2206.*	2206.*	478.*	478.*
	1908.1	1908.1	97.1	97.1	-322.1	-322.1	-1082.1	-1082.1	103.1	103.1	218.1	218.1
31.5*	501.*	501.*	10495.*	10495.*	-3218.*	-3218.*	-884.*	-884.*	2316.*	2316.*	501.*	501.*
	1817.1	1817.1	92.1	92.1	-307.1	-307.1	-1030.1	-1030.1	98.1	98.1	208.1	208.1
33.0*	525.*	525.*	10994.*	10994.*	-3371.*	-3371.*	-927.*	-927.*	2427.*	2427.*	525.*	525.*
	1734.1	1734.1	88.1	88.1	-293.1	-293.1	-983.1	-983.1	94.1	94.1	198.1	198.1
34.5*	549.*	549.*	11494.*	11494.*	-3525.*	-3525.*	-969.*	-969.*	2537.*	2537.*	549.*	549.*
	1659.1	1659.1	84.1	84.1	-280.1	-280.1	-940.1	-940.1	90.1	90.1	190.1	190.1
B-75												
39.0*	621.*	621.*	12993.*	12993.*	-3984.*	-3984.*	-1095.*	-1095.*	2868.*	2868.*	621.*	621.*
	1461.1	1461.1	74.1	74.1	-246.1	-246.1	-828.1	-828.1	79.1	79.1	167.1	167.1
40.5*	645.*	645.*	13493.*	13493.*	-4138.*	-4138.*	-1137.*	-1137.*	2978.*	2978.*	645.*	645.*
	1403.1	1403.1	71.1	71.1	-237.1	-237.1	-796.1	-796.1	76.1	76.1	161.1	161.1
42.0*	669.*	669.*	13993.*	13993.*	-4291.*	-4291.*	-1179.*	-1179.*	3089.*	3089.*	669.*	669.*
	1350.1	1350.1	68.1	68.1	-228.1	-228.1	-766.1	-766.1	73.1	73.1	155.1	155.1
43.5*	693.*	693.*	14493.*	14493.*	-4444.*	-4444.*	-1221.*	-1221.*	3199.*	3199.*	693.*	693.*
	1301.1	1301.1	66.1	66.1	-219.1	-219.1	-738.1	-738.1	70.1	70.1	149.1	149.1
45.0*	716.*	716.*	14992.*	14992.*	-4597.*	-4597.*	-1264.*	-1264.*	3309.*	3309.*	716.*	716.*
	1255.1	1255.1	64.1	64.1	-212.1	-212.1	-712.1	-712.1	68.1	68.1	144.1	144.1

GEAR LOADS DURING MAXIMUM TRACTIVE EFFORT CONDITION														
RUN DATE: NO. 7-AUG-85:9														
MAX *INNER *OUTER *PROP *OUTER *INNER *OUTER *INNER *OUTER *INNER *OUTER *INNER *OUTER *INNER *OUTER														
VEH *SPROK *MOTOR *B *C *D *E *F *G *H *I *J *K *L *M														
RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM														
TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE														
FT-LBS FT-LBS FT-LBS FT-LBS FT-LBS FT-LBS FT-LBS FT-LBS FT-LBS FT-LBS FT-LBS FT-LBS FT-LBS FT-LBS FT-LBS														
10.5*	167.*	167.*	3525.*	2154.*	0.*	0.*	669.*	669.*	-334.*	0.*	0.*	0.*	0.*	0.*
	5201.*	5201.*	254.*	-3.*	-3.*	1053.*	1053.*	1320.*	-7.*	-7.*	3842.*	3842.*	1060.*	8301.*
12.0*	191.*	191.*	4029.*	2462.*	0.*	0.*	764.*	764.*	-382.*	0.*	0.*	0.*	0.*	0.*
	4576.*	4576.*	224.*	-3.*	-3.*	927.*	927.*	1161.*	-6.*	-6.*	3380.*	3380.*	932.*	7303.*
13.5*	215.*	215.*	4533.*	2770.*	0.*	0.*	860.*	860.*	-430.*	0.*	0.*	0.*	0.*	0.*
	4090.*	4090.*	200.*	-2.*	-2.*	828.*	828.*	1038.*	-5.*	-5.*	3021.*	3021.*	833.*	6527.*
15.0*	239.*	239.*	5036.*	3078.*	0.*	0.*	955.*	955.*	-478.*	0.*	0.*	0.*	0.*	0.*
	3701.*	3701.*	181.*	-2.*	-2.*	750.*	750.*	939.*	-5.*	-5.*	2734.*	2734.*	754.*	5907.*
16.5*	263.*	263.*	5540.*	3386.*	0.*	0.*	1051.*	1051.*	-525.*	0.*	0.*	0.*	0.*	0.*
	3383.*	3383.*	165.*	-2.*	-2.*	685.*	685.*	858.*	-4.*	-4.*	2499.*	2499.*	689.*	5399.*
18.0*	287.*	287.*	6044.*	3693.*	0.*	0.*	1146.*	1146.*	-573.*	0.*	0.*	0.*	0.*	0.*
	3118.*	3118.*	152.*	-2.*	-2.*	631.*	631.*	791.*	-4.*	-4.*	2303.*	2303.*	635.*	4976.*
19.5*	310.*	310.*	6547.*	4001.*	0.*	0.*	1242.*	1242.*	-621.*	0.*	0.*	0.*	0.*	0.*
	2878.*	2878.*	141.*	-2.*	-2.*	583.*	583.*	730.*	-4.*	-4.*	2126.*	2126.*	586.*	4593.*
21.0*	334.*	334.*	7051.*	4309.*	0.*	0.*	1337.*	1337.*	-669.*	0.*	0.*	0.*	0.*	0.*
	2671.*	2671.*	130.*	-2.*	-2.*	541.*	541.*	678.*	-3.*	-3.*	1974.*	1974.*	544.*	4264.*
22.5*	358.*	358.*	7555.*	4617.*	0.*	0.*	1433.*	1433.*	-716.*	0.*	0.*	0.*	0.*	0.*
	2493.*	2493.*	122.*	-1.*	-1.*	505.*	505.*	633.*	-3.*	-3.*	1842.*	1842.*	508.*	3979.*
24.0*	382.*	382.*	8058.*	4924.*	0.*	0.*	1528.*	1528.*	-764.*	0.*	0.*	0.*	0.*	0.*
	2337.*	2337.*	114.*	-1.*	-1.*	473.*	473.*	593.*	-3.*	-3.*	1726.*	1726.*	476.*	3729.*
25.5*	406.*	406.*	8562.*	5232.*	0.*	0.*	1624.*	1624.*	-812.*	0.*	0.*	0.*	0.*	0.*
	2199.*	2199.*	107.*	-1.*	-1.*	445.*	445.*	558.*	-3.*	-3.*	1624.*	1624.*	448.*	3509.*
27.0*	430.*	430.*	9066.*	5540.*	0.*	0.*	1719.*	1719.*	-860.*	0.*	0.*	0.*	0.*	0.*
	2076.*	2076.*	101.*	-1.*	-1.*	421.*	421.*	527.*	-3.*	-3.*	1534.*	1534.*	423.*	3314.*

GEAR LOADS AT MAXIMUM TRACKTIVE EFFORT CONDITION												
RUN DATE: NO. 7-AUG-85: 7												
MAX *INNER	*OUTER	*INNER	*OUTER	*INNER	*OUTER	*INNER	*OUTER	*INNER	*OUTER			
VEH *SPROK	*MOTOR	*A	*B	*C	*D	*E	*F	*G	*G			
RPM *RPM	*RPM	*RPM	*RPM	*RPM	*RPM	*RPM	*RPM	*RPM	*RPM			
TORQUE	TORQUE	TORQUE	TORQUE	TORQUE	TORQUE	TORQUE	TORQUE	TORQUE	TORQUE			
lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs	lbs			
10.5#	167.0	3502.0	-4002.0	1273.0	1273.0	-1676.0	0.0	0.0	461.0	-607.0	0.0	0.0
11.0#	5036.0	5035.0	-84.0	74.0	661.0	661.0	-137.0	-137.0	1824.0	1824.0	-188.0	-2026.0
12.0#	191.0	4002.0	-4573.0	1455.0	1455.0	-1915.0	0.0	0.0	527.0	527.0	-694.0	0.0
13.0#	4444.0	4444.0	-74.0	65.0	583.0	583.0	-121.0	-121.0	1610.0	1610.0	-166.0	-1788.0
13.5#	215.0	4502.0	-5145.0	1637.0	1637.0	-2154.0	0.0	0.0	593.0	593.0	-781.0	0.0
14.0#	3984.0	3984.0	-67.0	58.0	523.0	523.0	-108.0	-108.0	1444.0	1444.0	-149.0	-1603.0
15.0#	239.0	5003.0	-5717.0	1819.0	1819.0	-2394.0	0.0	0.0	659.0	659.0	-867.0	0.0
15.5#	3597.0	3597.0	-60.0	53.0	472.0	472.0	-98.0	-98.0	1303.0	1303.0	-135.0	-1447.0
16.5#	263.0	5503.0	-6288.0	2001.0	2001.0	-2633.0	0.0	0.0	725.0	725.0	-954.0	0.0
17.0#	3281.0	3280.0	-55.0	48.0	431.0	431.0	-89.0	-89.0	1189.0	1189.0	-123.0	-1320.0
18.0#	287.0	6003.0	-6860.0	2183.0	2183.0	-2872.0	0.0	0.0	791.0	791.0	-1041.0	0.0
18.5#	3017.0	3017.0	-50.0	44.0	396.0	396.0	-82.0	-82.0	1093.0	1093.0	-113.0	-1214.0
19.5#	310.0	6503.0	-7432.0	2365.0	2365.0	-3112.0	0.0	0.0	857.0	857.0	-1127.0	0.0
20.0#	2784.0	2783.0	-47.0	41.0	365.0	365.0	-75.0	-75.0	1009.0	1009.0	-104.0	-1120.0
21.0#	334.0	7004.0	-8004.0	2547.0	2547.0	-3351.0	0.0	0.0	923.0	923.0	-1214.0	0.0
21.5#	2583.0	2582.0	-43.0	38.0	339.0	339.0	-70.0	-70.0	936.0	936.0	-97.0	-1039.0
22.5#	358.0	7504.0	-8575.0	2729.0	2729.0	-3590.0	0.0	0.0	989.0	989.0	-1301.0	0.0
23.0#	2408.0	2408.0	-40.0	35.0	316.0	316.0	-65.0	-65.0	873.0	873.0	-90.0	-969.0
24.0#	382.0	8004.0	-9147.0	2911.0	2911.0	-3830.0	0.0	0.0	1055.0	1055.0	-1388.0	0.0
25.0#	2254.0	2254.0	-38.0	33.0	296.0	296.0	-61.0	-61.0	817.0	817.0	-84.0	-907.0
25.5#	406.0	8504.0	-9719.0	3093.0	3093.0	-4069.0	0.0	0.0	1120.0	1120.0	-1474.0	0.0
26.0#	2119.0	2119.0	-35.0	31.0	278.0	278.0	-57.0	-57.0	768.0	768.0	-79.0	-852.0
27.0#	430.0	9005.0	-10291.0	3274.0	3274.0	-4308.0	0.0	0.0	1186.0	1186.0	-1561.0	0.0
28.0#	1998.0	1997.0	-33.0	29.0	262.0	262.0	-54.0	-54.0	724.0	724.0	-75.0	-803.0

GEAR LOADS AT MAXIMUM TRACKTIVE EFFORT CONDITION
 RUN DATE: NO. 7-AUG-85: 7
 MAX *INNER *OUTER* INNER *OUTER *INNER *OUTER *INNER *OUTER *INNER *OUTER *INNER *OUTER *INNER *OUTER *
 VEH *SPROK *MOTOR *MOTOR * A * B * C * D * E * F * G *
 MPH * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM *
 |TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|
 |ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|ftxlbs|

28.5*	454.*	9505.*	9505.*	-10862*	-10862*	3456.*	3456.*	-4548.*	0.*	0.*	1252.*	1252.*	-1648.*	0.*	0.*					
	1888.*	-32.*	28.*	28.*	28.*	248.*	248.*	-51.*	-51.*	-275.*	684.*	684.*	-71.*	-71.*	-759					
30.0*	478.*	10005.*	10005.*	-11434*	-11434*	3638.*	3638.*	-4787.*	0.*	0.*	1318.*	1318.*	-1734.*	0.*	0.*					
	1790.*	-30.*	26.*	26.*	26.*	235.*	235.*	-49.*	-49.*	-261.*	648.*	648.*	-67.*	-67.*	-720					
31.5*	501.*	10505.*	10505.*	-12006*	-12006*	3820.*	3820.*	-5027.*	0.*	0.*	1384.*	1384.*	-1821.*	0.*	0.*					
	1700.*	-28.*	25.*	25.*	25.*	223.*	223.*	-46.*	-46.*	-248.*	616.*	616.*	-64.*	-64.*	-683					
33.0*	525.*	11006.*	11006.*	-12577*	-12577*	4002.*	4002.*	-5266.*	0.*	0.*	1450.*	1450.*	-1908.*	0.*	0.*					
	1615.*	-27.*	24.*	24.*	24.*	212.*	212.*	-44.*	-44.*	-235.*	585.*	585.*	-60.*	-60.*	-649					
34.5*	549.*	11506.*	11506.*	-13149*	-13149*	4184.*	4184.*	-5505.*	0.*	0.*	1516.*	1516.*	-1995.*	0.*	0.*					
	1537.*	-26.*	22.*	22.*	22.*	202.*	202.*	-42.*	-42.*	-224.*	557.*	557.*	-58.*	-58.*	-618					
36.0*	573.*	12006.*	12006.*	-13721*	-13721*	4366.*	4366.*	-5745.*	0.*	0.*	1582.*	1582.*	-2081.*	0.*	0.*					
	1465.*	-24.*	21.*	21.*	21.*	192.*	192.*	-40.*	-40.*	-214.*	531.*	531.*	-55.*	-55.*	-589					
37.5*	597.*	12507.*	12507.*	-14293*	-14293*	4548.*	4548.*	-5984.*	0.*	0.*	1648.*	1648.*	-2168.*	0.*	0.*					
	1397.*	-23.*	20.*	20.*	20.*	183.*	183.*	-38.*	-38.*	-204.*	506.*	506.*	-52.*	-52.*	-561					
39.0*	621.*	13007.*	13007.*	-14864*	-14864*	4730.*	4730.*	-6223.*	0.*	0.*	1714.*	1714.*	-2255.*	0.*	0.*					
	1335.*	-22.*	20.*	20.*	20.*	175.*	175.*	-36.*	-36.*	-195.*	484.*	484.*	-50.*	-50.*	-537					
40.5*	645.*	13507.*	13507.*	-15436*	-15436*	4912.*	4912.*	-6463.*	0.*	0.*	1780.*	1780.*	-2342.*	0.*	0.*					
	1275.*	-21.*	19.*	19.*	19.*	167.*	167.*	-35.*	-35.*	-186.*	462.*	462.*	-48.*	-48.*	-513					
42.0*	669.*	14007.*	14007.*	-16008*	-16008*	5094.*	5094.*	-6702.*	0.*	0.*	1845.*	1845.*	-2428.*	0.*	0.*					
	1219.*	-20.*	18.*	18.*	18.*	160.*	160.*	-33.*	-33.*	-178.*	442.*	442.*	-46.*	-46.*	-490					
43.5*	693.*	14508.*	14508.*	-16580*	-16580*	5275.*	5275.*	-6941.*	0.*	0.*	1911.*	1911.*	-2515.*	0.*	0.*					
	1167.*	-20.*	17.*	17.*	17.*	153.*	153.*	-32.*	-32.*	-170.*	423.*	423.*	-44.*	-44.*	-469					
45.0*	716.*	15008.*	15008.*	-17151*	-17151*	5457.*	5457.*	-7181.*	0.*	0.*	1977.*	1977.*	-2602.*	0.*	0.*					
	1119.*	-19.*	16.*	16.*	16.*	147.*	147.*	-30.*	-30.*	-163.*	405.*	405.*	-42.*	-42.*	-450					

GEAR LOADS DURING MAXIMUM TRACTIVE EFFORT CONDITION

BY: RICK LEWIS; REVISION: 8-JUN-85
RUN DATE: 20-AUG-85:109

INPUT DATA:

GROSS VEHICLE WEIGHT, tons = 40.0 MAXIMUM VELOCITY, mph = 45.0 ENGINE NET HP. = 880.0
TRACK PITCH, in. = 7.63 NUMBER OF SPROCKET TEETH = 11

Efficiency data for Westinghouse induction motor # CONFIGURATION I
by Craig Joseph 10-MAY-85 TWIN DRIVE MOTOR SET-UP

VEH #	SPROK	INNER	OUTER	MOTOR=A	INNER	OUTER	INNER	OUTER	C & D	INNER	OUTER	INNER	OUTER	E	INNER	OUTER	F
MPH #	RPM	TORQUE	ftxlbs	RPM	TORQUE	ftxlbs	RPM	TORQUE	ftxlbs	RPM	TORQUE	ftxlbs	RPM	TORQUE	ftxlbs	RPM	TORQUE
1	39569.1	3956.1	2004.1	2003.1	-6676.1	-6676.1	-6676.1	-6676.1	-22436.1	-22436.1	-22436.1	-22436.1	-22436.1	-22436.1	-22436.1	-22436.1	-22436.1
4.5#	57.5	57.5	1196.5	1186.5	-364.5	-364.5	-364.5	-364.5	-100.5	-100.5	-100.5	-100.5	-100.5	-100.5	-100.5	-100.5	-100.5
1	28328.1	2832.8	1435.1	1434.1	-4779.1	-4779.1	-4779.1	-4779.1	-16062.1	-16062.1	-16062.1	-16062.1	-16062.1	-16062.1	-16062.1	-16062.1	-16062.1
6.0#	76.5	76.5	1581.5	1581.5	-485.5	-485.5	-485.5	-485.5	-133.5	-133.5	-133.5	-133.5	-133.5	-133.5	-133.5	-133.5	-133.5
1	22120.1	2212.0	1120.1	1120.1	-3732.1	-3732.1	-3732.1	-3732.1	-12542.1	-12542.1	-12542.1	-12542.1	-12542.1	-12542.1	-12542.1	-12542.1	-12542.1
7.5#	94.5	94.5	1976.5	1976.5	-606.5	-606.5	-606.5	-606.5	-167.5	-167.5	-167.5	-167.5	-167.5	-167.5	-167.5	-167.5	-167.5
1	18085.1	1808.5	916.1	916.1	-3051.1	-3051.1	-3051.1	-3051.1	-10255.1	-10255.1	-10255.1	-10255.1	-10255.1	-10255.1	-10255.1	-10255.1	-10255.1
9.0#	113.5	113.5	2371.5	2371.5	-727.5	-727.5	-727.5	-727.5	-200.5	-200.5	-200.5	-200.5	-200.5	-200.5	-200.5	-200.5	-200.5
1	15397.1	1539.7	780.1	780.1	-2598.1	-2598.1	-2598.1	-2598.1	-8730.1	-8730.1	-8730.1	-8730.1	-8730.1	-8730.1	-8730.1	-8730.1	-8730.1

GEAR LOADS AT MAXIMUM TRACTIVE EFFORT CONDITION

RUN DATE: No. 20-AUG-85:109

RUN DATE: NO. 20-AUG-85 109																														
MAX #	INNER	SPROK	VEH #	INNER	SPROK	VEH #	INNER	SPROK	VEH #	INNER	SPROK	VEH #	INNER	SPROK	VEH #	INNER	SPROK	VEH #	INNER	SPROK	VEH #	INNER	SPROK	VEH #	INNER	SPROK	VEH #	INNER	SPROK	VEH #
MPH #	RPM	TORQUE	ftlbs	RPM	TORQUE	ftlbs	RPM	TORQUE	ftlbs	RPM	TORQUE	ftlbs	RPM	TORQUE	ftlbs	RPM	TORQUE	ftlbs	RPM	TORQUE	ftlbs	RPM	TORQUE	ftlbs	RPM	TORQUE	ftlbs	RPM	TORQUE	ftlbs
28.5*	359.*	5082.1	359.*	7509.*	7509.*	257.1	257.1	5082.1	359.*	7509.*	7509.*	257.1	257.1	5082.1	359.*	7509.*	7509.*	257.1	257.1	5082.1	359.*	7509.*	7509.*	257.1	257.1	5082.1	359.*	7509.*	7509.*	257.1
30.0*	378.*	4826.1	378.*	8299.*	8299.*	244.1	244.1	4826.1	378.*	8299.*	8299.*	244.1	244.1	4826.1	378.*	8299.*	8299.*	244.1	244.1	4826.1	378.*	8299.*	8299.*	244.1	244.1	4826.1	378.*	8299.*	8299.*	244.1
31.5*	397.*	4596.1	397.*	8695.*	8695.*	222.1	222.1	4596.1	397.*	8695.*	8695.*	222.1	222.1	4596.1	397.*	8695.*	8695.*	222.1	222.1	4596.1	397.*	8695.*	8695.*	222.1	222.1	4596.1	397.*	8695.*	8695.*	222.1
33.0*	415.*	4386.1	415.*	9090.*	9090.*	212.1	212.1	4386.1	415.*	9090.*	9090.*	212.1	212.1	4386.1	415.*	9090.*	9090.*	212.1	212.1	4386.1	415.*	9090.*	9090.*	212.1	212.1	4386.1	415.*	9090.*	9090.*	212.1
34.5*	434.*	4194.1	434.*	9485.*	9485.*	204.1	204.1	4194.1	434.*	9485.*	9485.*	204.1	204.1	4194.1	434.*	9485.*	9485.*	204.1	204.1	4194.1	434.*	9485.*	9485.*	204.1	204.1	4194.1	434.*	9485.*	9485.*	204.1
36.0*	453.*	4019.1	453.*	10275.*	10275.*	187.1	187.1	4019.1	453.*	10275.*	10275.*	187.1	187.1	4019.1	453.*	10275.*	10275.*	187.1	187.1	4019.1	453.*	10275.*	10275.*	187.1	187.1	4019.1	453.*	10275.*	10275.*	187.1
38.0*	472.*	3850.1	472.*	10671.*	10671.*	180.1	180.1	3850.1	472.*	10671.*	10671.*	180.1	180.1	3850.1	472.*	10671.*	10671.*	180.1	180.1	3850.1	472.*	10671.*	10671.*	180.1	180.1	3850.1	472.*	10671.*	10671.*	180.1
39.0*	491.*	3694.1	491.*	11066.*	11066.*	173.1	173.1	3694.1	491.*	11066.*	11066.*	173.1	173.1	3694.1	491.*	11066.*	11066.*	173.1	173.1	3694.1	491.*	11066.*	11066.*	173.1	173.1	3694.1	491.*	11066.*	11066.*	173.1
40.5*	510.*	3549.1	510.*	11856.*	11856.*	167.1	167.1	3549.1	510.*	11856.*	11856.*	167.1	167.1	3549.1	510.*	11856.*	11856.*	167.1	167.1	3549.1	510.*	11856.*	11856.*	167.1	167.1	3549.1	510.*	11856.*	11856.*	167.1
42.0*	529.*	3415.1	529.*	12251.*	12251.*	161.1	161.1	3415.1	529.*	12251.*	12251.*	161.1	161.1	3415.1	529.*	12251.*	12251.*	161.1	161.1	3415.1	529.*	12251.*	12251.*	161.1	161.1	3415.1	529.*	12251.*	12251.*	161.1
43.5*	548.*	3290.1	548.*	12646.*	12646.*	155.1	155.1	3290.1	548.*	12646.*	12646.*	155.1	155.1	3290.1	548.*	12646.*	12646.*	155.1	155.1	3290.1	548.*	12646.*	12646.*	155.1	155.1	3290.1	548.*	12646.*	12646.*	155.1
45.0*	567.*	3174.1	567.*	13041.*	13041.*	149.1	149.1	3174.1	567.*	13041.*	13041.*	149.1	149.1	3174.1	567.*	13041.*	13041.*	149.1	149.1	3174.1	567.*	13041.*	13041.*	149.1	149.1	3174.1	567.*	13041.*	13041.*	149.1
46.5*	586.*	3059.1	586.*	13436.*	13436.*	143.1	143.1	3059.1	586.*	13436.*	13436.*	143.1	143.1	3059.1	586.*	13436.*	13436.*	143.1	143.1	3059.1	586.*	13436.*	13436.*	143.1	143.1	3059.1	586.*	13436.*	13436.*	143.1

 GEAR LOADS DURING MAXIMUM TRACTIVE EFFORT CONDITION
 BY: RICK LEWIS; REVISION: 8-JUN-85
 RUN DATE: 14-AUG-85:110

INPUT DATA:

GROSS VEHICLE WEIGHT, tons = 40.0 MAXIMUM VELOCITY, mph = 45.0 ENGINE NET HP. = 880.0
 TRACK PITCH, in. = 7.63 NUMBER OF SPROCKET TEETH = 11

Efficiency data for Westinghouse Induction motor * CONFIGURATION II
 by Craig Joseph 10-MAY-85 PROPULSION/STEER MOTOR SET-UP

 MAX *INNER *OUTER *PROP *OUTER *INNER *OUTER *INNER *OUTER *INNER *STEER *H *J *K *L *
 VEH *SPROK *SPROK *MOTOR *B *B *C *C *D *D *E *E *F *F *MOTOR * * * * *
 MPH * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM * RPM *
 TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE
 ftxlbs ftxlbs ftxlbs ftxlbs ftxlbs ftxlbs ftxlbs ftxlbs ftxlbs ftxlbs ftxlbs ftxlbs ftxlbs ftxlbs ftxlbs
 1.5* 19.* 19.* 398.* 243.* 243.* 0.* 0.* 76.* 76.* -38.* -38.* 0.* 0.* 0.* 0.* 0.* 0.* 0.* 0.*
 153424.153424.1 2610.1 -32.1 10821.110821.113556.113556.1 -67.1 -67.139467.139467.1-6632.110885.185266.135074.1-9163.1
 3.0* 38.* 38.* 797.* 487.* 487.* 0.* 0.* 151.* 151.* -76.* -76.* 0.* 0.* 0.* 0.* 0.* 0.* 0.* 0.*
 138727.138727.1 1892.1 -23.1 7844.17844.19827.19827.1 -48.1 -48.128609.128609.1-4822.17891.161809.125425.1-6643.1
 4.5* 57.* 57.* 1195.* 730.* 730.* 0.* 0.* 227.* 227.* -113.* -113.* 0.* 0.* 0.* 0.* 0.* 0.* 0.* 0.*
 127725.127725.1 1354.1 -16.1 5616.15616.17035.17035.1 -35.1 -35.120482.120482.1-3452.15649.144250.118202.1-4755.1
 6.0* 76.* 76.* 1593.* 974.* 974.* 0.* 0.* 302.* 302.* -151.* -151.* 0.* 0.* 0.* 0.* 0.* 0.* 0.* 0.*
 121649.121649.1 1057.1 -13.1 4385.14385.15493.15493.1 -27.1 -27.115993.115993.1-2696.14411.134553.114213.1-3713.1
 7.5* 94.* 94.* 1991.* 1217.* 1217.* 0.* 0.* 378.* 378.* -189.* -189.* 0.* 0.* 0.* 0.* 0.* 0.* 0.* 0.*
 117701.117701.1 865.1 -10.1 3585.13585.14492.14492.1 -22.1 -22.113076.113076.1-2204.13606.128251.111621.1-3036.1
 9.0* 113.* 113.* 2390.* 1460.* 1460.* 0.* 0.* 453.* 453.* -227.* -227.* 0.* 0.* 0.* 0.* 0.* 0.* 0.* 0.*
 115070.115070.1 736.1 -9.1 3052.13052.13824.13824.1 -19.1 -19.111133.111133.1-1876.13070.124052.19894.1-2595.1

GEAR LOADS DURING MAXIMUM TRACTIVE EFFORT CONDITION

BY: RICK LEWIS; REVISION: 8-JUN-85

RUN DATE: 14-AUG-85:108

INPUT DATA:

GROSS VEHICLE WEIGHT, tons = 40.0 MAXIMUM VELOCITY, mph = 45.0 ENGINE NET HP. = 880.0
TRACK PITCH, in. = 7.63
NUMBER OF SPROCKET TEETH = 11

Efficiency data for Homopolar motor * CONFIGURATION I
by Gene Siedler 20-MAY-85 * TWIN DRIVE MOTOR SET-UP

MAX *INNER *OUTER *INNER *OUTER *INNER *OUTER *INNER *OUTER *INNER *OUTER *INNER *OUTER *
VEH *SPROK *MOTOR *MOTOR *A *A *B *B *C *C *D *D *E *E *F *F *G *G *
RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *
|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|TORQUE|
|ftlbs|ftlbs|ftlbs|ftlbs|ftlbs|ftlbs|ftlbs|ftlbs|ftlbs|ftlbs|ftlbs|ftlbs|ftlbs|ftlbs|
1.5* 19.* 396.* 396.* -452.* 144.* 144.* -189.* -189.* 0.* 0.* 52.* 52.* -69.* -69.* 0.* 0.*
148413.1484121 -809.1 -809.1 708.1 6355.1 6355.1 -1313.1 -1313.1 -7058.1 -7058.1 117541.1 117541.1 -1812.1 -1812.1 -194801 -194801
3.0* 38.* 791.* 791.* -904.* 288.* 288.* -379.* -379.* 0.* 0.* 104.* 104.* -137.* -137.* 0.* 0.*
138656.1386551 -646.1 -646.1 565.1 5075.1 5075.1 -1048.1 -1048.1 -5636.1 -5636.1 114006.1 114006.1 -1447.1 -1447.1 -155541 -155541
4.5* 57.* 1187.* 1187.* -1356.* 432.* 432.* -568.* -568.* 0.* 0.* 156.* 156.* -206.* -206.* 0.* 0.*
127349.1273491 -457.1 -457.1 400.1 3590.1 3590.1 -742.1 -742.1 -3987.1 -3987.1 9909.1 9909.1 -1024.1 -1024.1 -110041 -110041
6.0* 76.* 1582.* 1582.* -1808.* 575.* 575.* -757.* -757.* 0.* 0.* 208.* 208.* -274.* -274.* 0.* 0.*
121057.1210561 -352.1 -352.1 308.1 2764.1 2764.1 -571.1 -571.1 -3070.1 -3070.1 7629.1 7629.1 -788.1 -788.1 -84721 -84721
7.5* 94.* 1978.* 1978.* -2260.* 719.* 719.* -946.* -946.* 0.* 0.* 261.* 261.* -343.* -343.* 0.* 0.*
117285.1172851 -289.1 -289.1 253.1 2269.1 2269.1 -469.1 -469.1 -2520.1 -2520.1 6263.1 6263.1 -647.1 -647.1 -69551 -69551
9.0* 113.* 2374.* 2374.* -2712.* 863.* 863.* -1136.* -1136.* 0.* 0.* 313.* 313.* -411.* -411.* 0.* 0.*
114772.1147711 -247.1 -247.1 216.1 1939.1 1939.1 -401.1 -401.1 -2154.1 -2154.1 5352.1 5352.1 -553.1 -553.1 -59431 -59431

GEAR LOADS AT MAXIMUM TRACKTIVE EFFORT CONDITION														
RUN DATE: NO. 14-AUG-85: 108														
MAX *INNER *OUTER *INNER *OUTER *INNER *OUTER *INNER *OUTER *INNER *OUTER *INNER *OUTER *INNER *OUTER *														
VEH #SPROK *MOTOR *MOTOR *A *B *C *C *D *E *F *G *G *G *														
RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *RPM *														
TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE TORQUE														
ftlbs ftlbs ftlbs ftlbs ftlbs ftlbs ftlbs ftlbs ftlbs ftlbs ftlbs ftlbs ftlbs ftlbs														
28.5# 359.* 359.* 7517.* -8590.* -8590.* 2733.* 2733.* -3597.* 0.* 0.* 990.* 990.* -1303.* 0.* 0.*	4824.*	-81.*	-81.*	71.*	71.*	633.*	633.*	-131.*	-131.*	-703.*	1748.*	1748.*	-181.*	-1941.*
30.0# 378.* 378.* 7912.* -9042.* -9042.* 2877.* 2877.* -3786.* 0.* 0.* 1042.* 1042.* -1372.* 0.* 0.*	4577.*	-76.*	-76.*	67.*	67.*	601.*	601.*	-124.*	-124.*	-667.*	1658.*	1658.*	-171.*	-1841.*
31.5# 397.* 397.* 8308.* -9494.* -9494.* 3021.* 3021.* -3975.* 0.* 0.* 1095.* 1095.* -1440.* 0.* 0.*	4352.*	-73.*	-73.*	64.*	64.*	571.*	571.*	-118.*	-118.*	-634.*	1577.*	1577.*	-163.*	-1751.*
33.0# 415.* 415.* 8704.* -9946.* -9946.* 3165.* 3165.* -4164.* 0.* 0.* 1147.* 1147.* -1509.* 0.* 0.*	4139.*	-69.*	-69.*	61.*	61.*	543.*	543.*	-112.*	-112.*	-603.*	1500.*	1500.*	-155.*	-1665.*
34.5# 436.* 436.* 9099.* -10399.* -10399.* 3309.* 3309.* -4354.* 0.* 0.* 1199.* 1199.* -1577.* 0.* 0.*	3945.*	-66.*	-66.*	58.*	58.*	518.*	518.*	-107.*	-107.*	-575.*	1430.*	1430.*	-148.*	-1587.*
36.0# 453.* 453.* 9495.* -10851.* -10851.* 3453.* 3453.* -4543.* 0.* 0.* 1251.* 1251.* -1646.* 0.* 0.*	3766.*	-63.*	-63.*	55.*	55.*	494.*	494.*	-102.*	-102.*	-549.*	1365.*	1365.*	-141.*	-1515.*
37.5# 472.* 472.* 9890.* -11303.* -11303.* 3597.* 3597.* -4732.* 0.* 0.* 1303.* 1303.* -1715.* 0.* 0.*	3598.*	-60.*	-60.*	53.*	53.*	472.*	472.*	-98.*	-98.*	-525.*	1304.*	1304.*	-135.*	-1447.*
39.0# 491.* 491.* 10286.* -11755.* -11755.* 3740.* 3740.* -4922.* 0.* 0.* 1355.* 1355.* -1783.* 0.* 0.*	3444.*	-58.*	-58.*	50.*	50.*	452.*	452.*	-93.*	-93.*	-502.*	1248.*	1248.*	-129.*	-1385.*
40.5# 510.* 510.* 10682.* -12207.* -12207.* 3884.* 3884.* -5111.* 0.* 0.* 1407.* 1407.* -1852.* 0.* 0.*	3298.*	-55.*	-55.*	48.*	48.*	433.*	433.*	-89.*	-89.*	-481.*	1195.*	1195.*	-123.*	-1327.*
42.0# 529.* 529.* 11077.* -12659.* -12659.* 4028.* 4028.* -5300.* 0.* 0.* 1459.* 1459.* -1920.* 0.* 0.*	3161.*	-53.*	-53.*	46.*	46.*	415.*	415.*	-86.*	-86.*	-461.*	1145.*	1145.*	-118.*	-1271.*
43.5# 548.* 548.* 11473.* -13111.* -13111.* 4172.* 4172.* -5489.* 0.* 0.* 1512.* 1512.* -1989.* 0.* 0.*	3033.*	-51.*	-51.*	44.*	44.*	398.*	398.*	-82.*	-82.*	-442.*	1099.*	1099.*	-114.*	-1220.*
45.0# 567.* 567.* 11868.* -13563.* -13563.* 4316.* 4316.* -5679.* 0.* 0.* 1564.* 1564.* -2057.* 0.* 0.*	2914.*	-49.*	-49.*	43.*	43.*	383.*	383.*	-79.*	-79.*	-425.*	1056.*	1056.*	-109.*	-1172.*

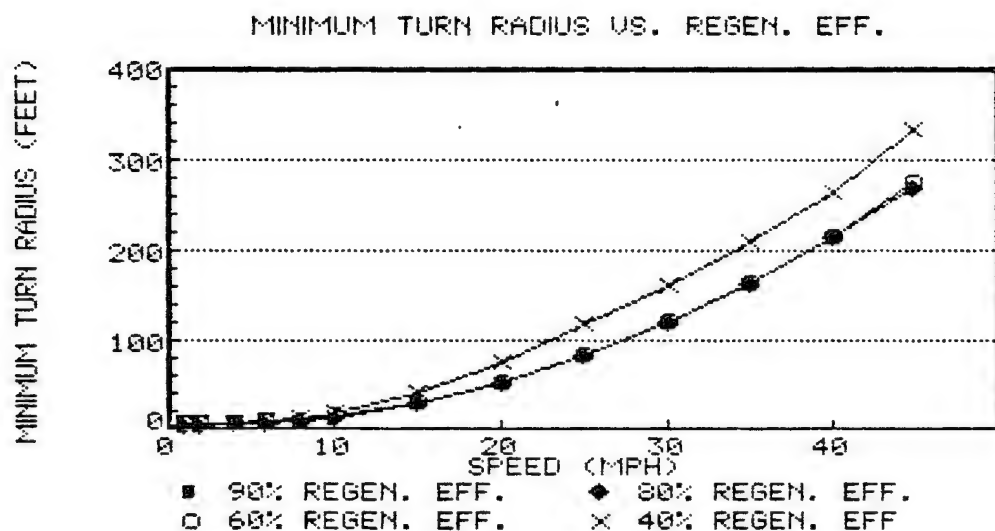
B.3 Regeneration In Steering

The effects of regeneration efficiency on steering performance were studied to quantify significance on this factor. The following curves illustrate the results of this study. The 19.5 ton vehicle parameters were used. The propulsive efficiency of the drive was based on the homopolar system, which is only slightly lower than the induction motor systems. Regeneration efficiency was varied as noted to determine the effects.

1. Figure B.3-1: These curves show that regeneration efficiencies of 60% or better will provide the same minimum turn radius.
2. Figure B.3-2: These curves show that regeneration efficiencies of 60% or better will provide the 0.5 G. lateral acceleration that is desirable for evasive maneuvers.
3. Figure B.3-3: These curves show that power requirements in turns decreases with improved regeneration efficiency, which will reduce fuel consumption.
4. Figure B.3-4: These curves show that improved regeneration efficiency increases outer sprocket maximum loads, potentially increasing the required size of motors and related gearing.
5. Figure B.3-5: These curves show that regeneration horsepower is constant with regeneration efficiencies of 60% or greater.
6. Figure B.3-6: These curves show regeneration efficiency indirectly changes scrub horsepower due to more scrubbing in the sharper turn.
7. Figure B.3-7: These curves show the effect of sharper turns on regenerated horsepower at 90% regeneration efficiency and that the resulting higher powers impose greater loads on system components.

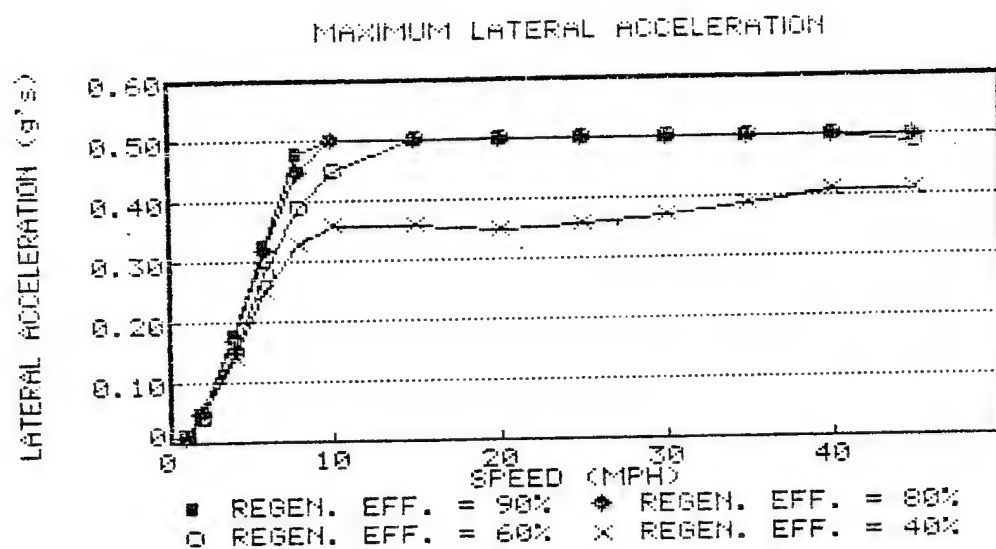
The conclusion from the data provided by these curves was that regeneration efficiencies of 60% or better would provide satisfactory performance. Since all recommended drives provided the desired level of regeneration efficiency, this characteristic did not become a factor for discriminating between the various drives.

X Data	90% REGEN. EFF.	80% REGEN. EFF.	60% REGEN. EFF.	40% REGEN. EFF.
1	5.28	5.48	5.88	6.29
2	5.31	5.50	6.06	6.62
4	6.06	6.38	7.02	7.86
6	7.20	7.61	8.58	9.81
8	8.84	9.46	10.97	12.98
10	13.40	13.40	14.88	18.59
15	30.15	30.15	30.15	41.54
20	53.60	53.60	53.60	76.43
25	83.75	83.75	83.75	117.64
30	120.60	120.60	120.60	161.86
35	164.15	164.15	164.15	209.92
40	214.40	214.40	214.40	263.90
45	271.35	271.35	276.64	332.37



X Data REGEN. EFF. = 90% REGEN. EFF. = 80% REGEN. EFF. = 60% REGEN. EFF. = 40%

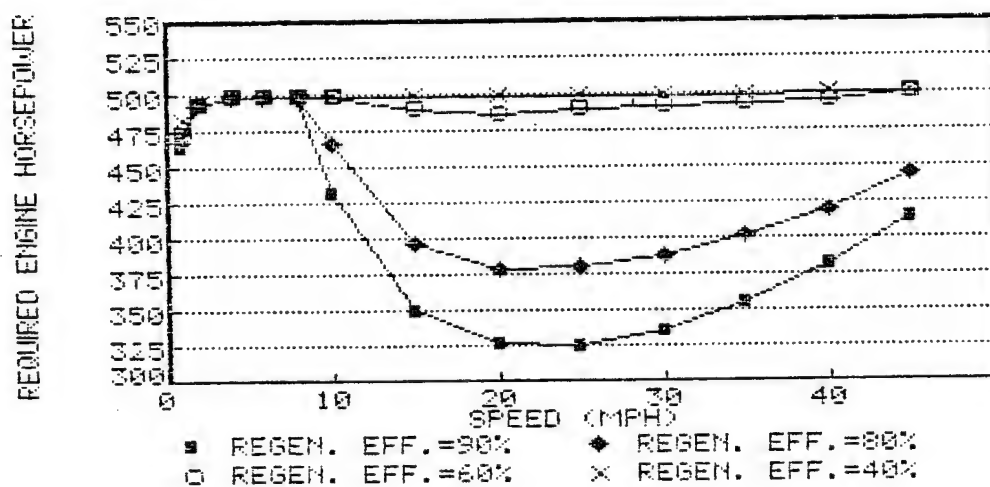
1	0.01	0.01	0.01	0.01
2	0.05	0.05	0.04	0.04
4	0.18	0.17	0.15	0.14
6	0.33	0.32	0.28	0.25
8	0.48	0.45	0.39	0.33
10	0.50	0.50	0.45	0.36
15	0.50	0.50	0.50	0.36
20	0.50	0.50	0.50	0.36
25	0.50	0.50	0.50	0.37
30	0.50	0.50	0.50	0.39
35	0.50	0.50	0.50	0.39
40	0.50	0.50	0.50	0.41
45	0.50	0.50	0.49	0.41



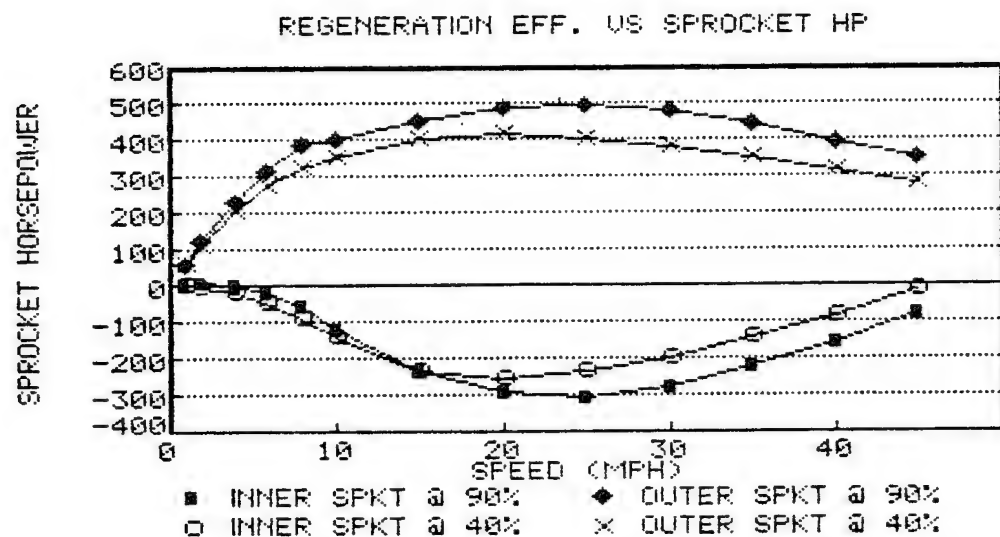
X Data REGEN. EFF.=90% REGEN. EFF.=80% REGEN. EFF.=60% REGEN. EFF.=40%

1	466	468	474	483
2	493	493	494	494
4	499	499	499	499
6	499	499	499	499
8	499	499	499	499
10	433	467	499	499
15	351	397	490	499
20	327	380	486	499
25	326	381	490	499
30	337	388	492	499
35	356	402	493	499
40	383	420	496	500
45	416	446	500	500

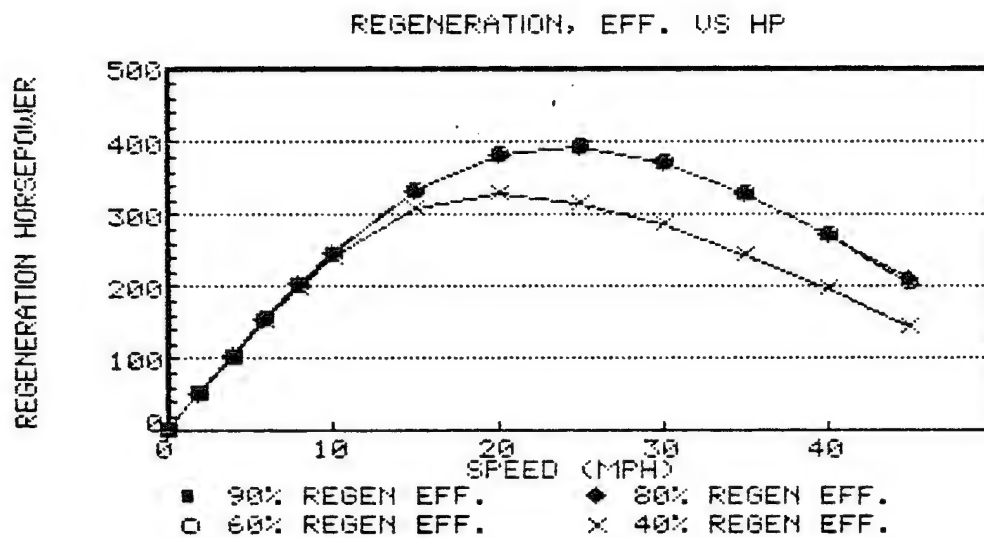
REQUIRED ENG. HP AT MAX. STEER CONDITION



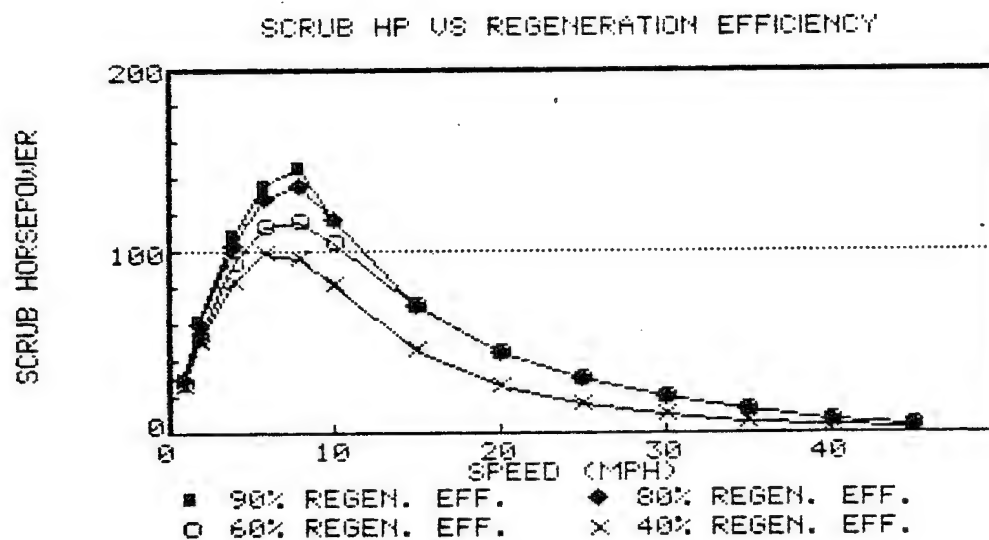
X Data	INNER SPKT @ 90%	OUTER SPKT @ 90%	INNER SPKT @ 40%	OUTER SPK
1	4.73	63.27	0.21	57.42
2	9.15	126.15	-1.94	111.72
4	4.43	234.40	-17.86	204.68
6	-16.57	320.93	-48.30	276.71
8	-51.80	387.11	-91.06	327.51
10	-116.86	404.26	-140.81	357.07
15	-232.50	452.45	-229.44	403.59
20	-290.43	488.21	-254	416
25	-301.40	497.20	-235.33	405.57
30	-274.45	480.19	-194.63	383.54
35	-220.37	444.44	-140.86	354.32
40	-150.54	399.49	-78.98	321.35
45	-75.10	354.42	-7.91	282.79



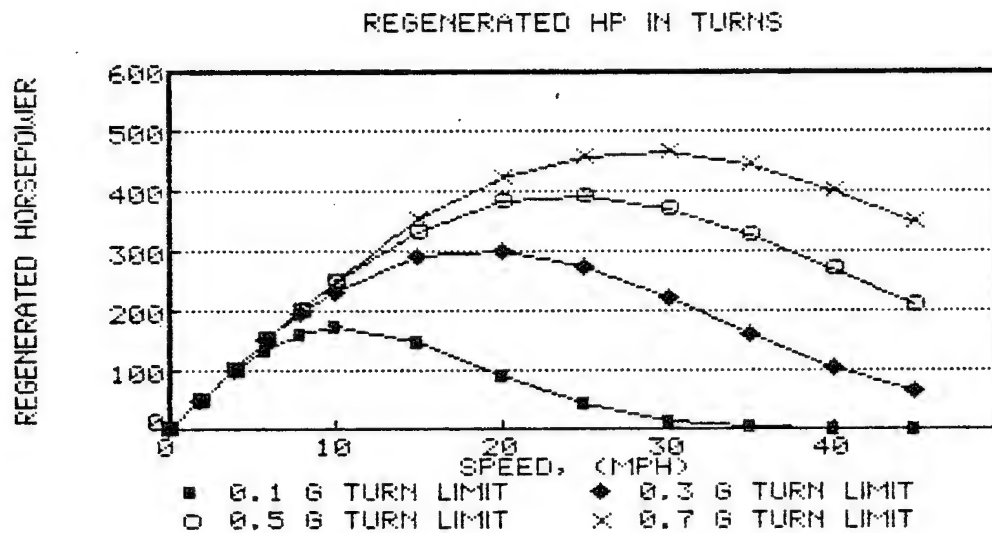
X Data	90% REGEN EFF.	80% REGEN EFF.	60% REGEN EFF.	40% REGEN EFF.
0	0	0	0	0
2	52	52	52	52
4	104	104	103	103
6	155	155	154	152
8	204	204	202	199
10	248	248	246	240
15	334	334	334	310
20	383	383	383	331
25	394	394	394	317
30	373	373	373	286
35	329	329	329	245
40	272	272	272	197
45	212	212	205	143



X Data	90% REGEN. EFF.	80% REGEN. EFF.	60% REGEN. EFF.	40% REGEN. EFF.
1	31	30	28	26
2	62	60	54	50
4	109	103	93	83
6	137	129	114	99
8	147	137	117	97
10	118	118	105	82
15	70	70	70	47
20	45	45	45	27
25	30	30	30	17
30	20	20	20	11
35	13	13	13	7
40	8	8	8	5
45	5	5	5	3



X Data	0.1 G TURN LIMIT	0.3 G TURN LIMIT	0.5 G TURN LIMIT	0.7 G TUR
0	0	0	0	0
2	52	52	52	52
4	101	104	104	104
6	139	154	155	155
8	164	197	204	204
10	175	234	248	252
15	152	293	334	353
20	95	304	383	423
25	44	275	394	460
30	16	222	373	466
35	5	162	329	445
40	1	108	272	403
45	0	66	212	349



B.4 Impact Of Grades On Motor Loads While Steering

Data for turns on grades was evaluated and found to produce high momentary loads that are within the thermal limits of the drive components. Two curve sets were produced to investigate alternate operational assumptions.

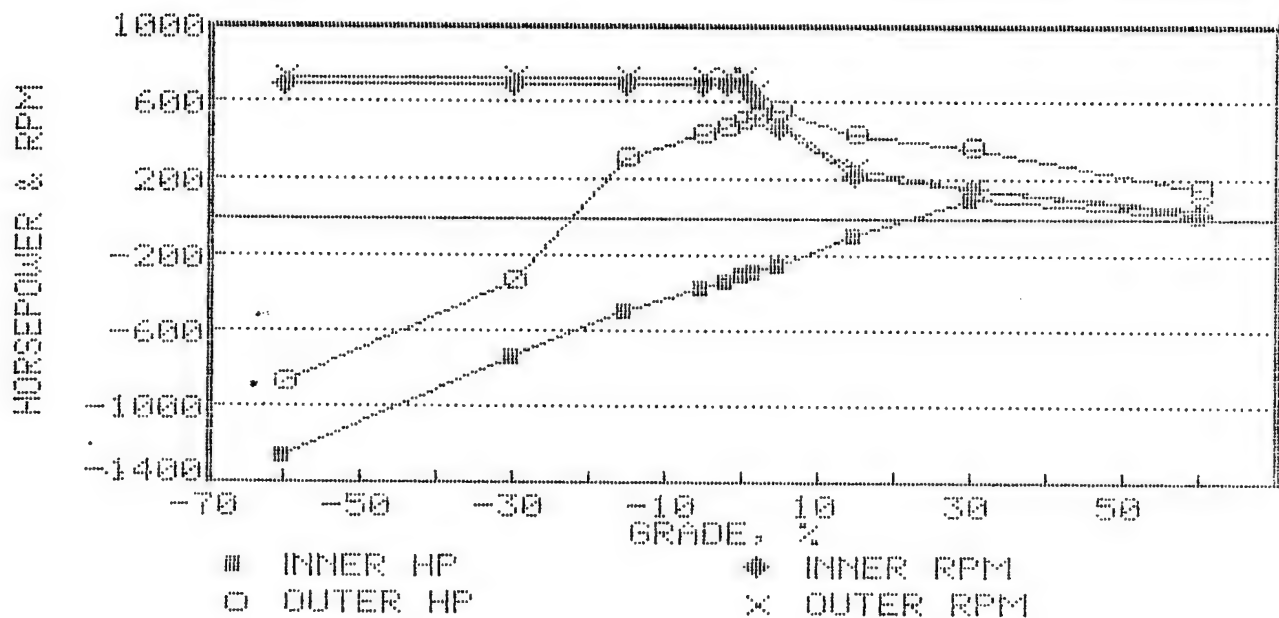
The first set (Figure B.4-1) are titled "Grade vs. Maximum Sprocket HP & RPM". These curves plot the speeds and loads for the highest horsepowers and RPM that are theoretically possible. The power inputs from the ground (indicated as horsepower) become very high under certain conditions. The implied operation that produced these results cover some areas that are unrealistic combinations of speed, grade and turn radius. It is considered unlikely that a driver will make the sharpest possible turn, at maximum speed on the steepest downgrade.

The second set of curves (Figure B.4-2) titled "Grade vs. Maximum Sprocket HP & RPM (LTD)" represent a more limited operational envelope. Downhill speeds are limited to the speeds that the vehicle can achieve on upgrades. These curves are considered representative of a prudent driver under normal operating conditions.

All points on the "LTD" curve are easily within the momentary overload capacity of the drives, which is considered reasonable for turning requirements. Downgrades steeper than 40% impose excessive loads at maximum 45 MPH speed, but operation at this combination of grade and speed is considered unrealistic. It was therefore concluded that normal turns on grades could present no peculiar load problems for the recommended electric drive systems.

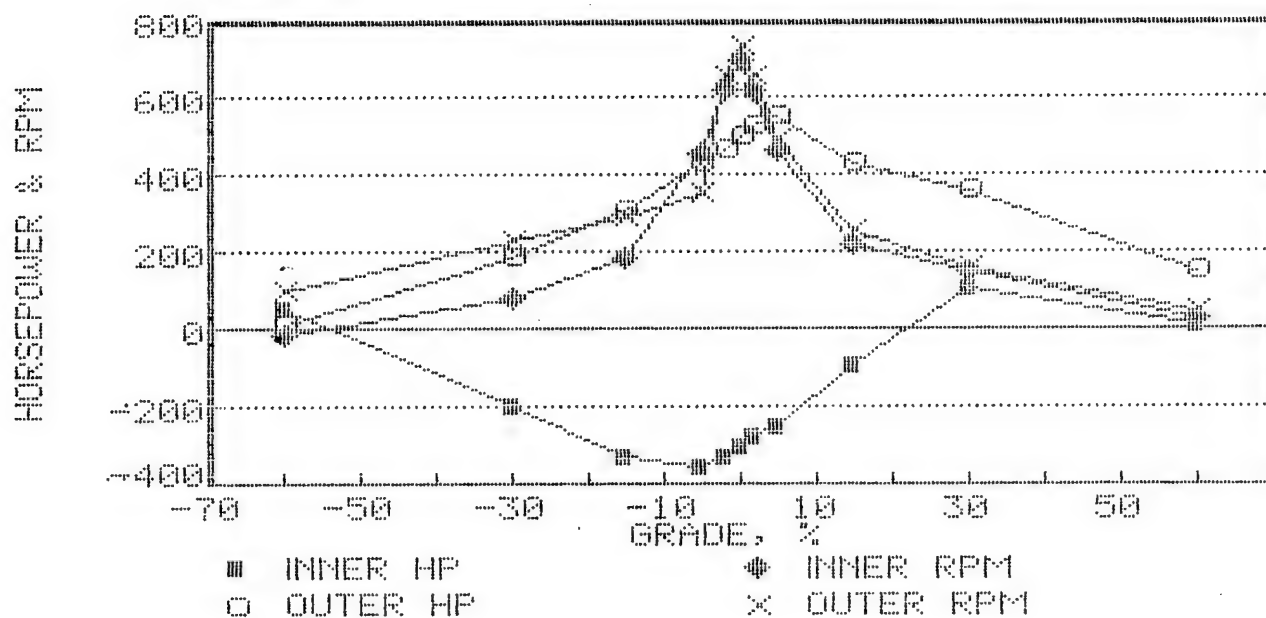
X Data	INNER HP	INNER RPM	OUTER HP	OUTER RPM
-60	-1250.89	699.67	-877.63	733.17
-30	-731	699.67	-333.68	733.17
-15	-493.71	699.67	315.70	733.17
-5	-361.42	699.67	430.15	733.17
-2	-325.45	699.67	469.25	733.17
0	-301.42	699.67	497.22	733.17
2	-277.40	617.97	525.18	655.66
5	-244.67	462.01	556.30	493.21
15	-93	223.28	430.98	254.34
30	111.69	154.84	361.74	163.57
60	16.49	32.89	148.84	46.71

GRADE VS MAXIMUM SPROCKET HP & RPM



X Data	INNER HP	INNER RPM	OUTER HP	OUTER RPM
-60	54.12	-17.08	13	96.68
-30	-195.50	83.83	184.11	234.58
-15	-323.88	188.55	312.41	289.06
-5	-348.27	452.49	430.15	356.10
-2	-325.45	617.97	469.25	655.66
0	-301.42	699.67	497.22	733.17
2	-277.40	617.97	525.18	655.66
5	-244.67	462.01	556.30	493.21
15	-93	223.28	430.98	254.34
30	111.69	154.84	361.74	163.57
60	16.49	32.89	148.84	46.71

GRADE VS MAX SPROCKET HP & RPM (LTD.)



SPROCKET HORSEPOWER

CODE:#2TRN

BY:W.E. RODLER

L.M. FERNANDEZ

REV. DATE: 91984

RUN DATE:52985.11

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5
MAXIMUM VELOCITY, mph= 45
ENGINE GROSS HP= 500
LOSS ENGINE HP= 60
FRONTAL AREA, in= 57
COEFFICIENT OF DRAG= 1
TREAD WIDTH, in= 92.5
TRACK LENGTH, in= 150
TRACK PITCH, in= 6.03
NUMBER OF SPROCKET TEETH= 11
ROLLING RESISTANCE, lb per ton= 100
GRADE, %=-60
COEFFICIENT OF FRICTION= .7
MAXIMUM ACCELERATION, gs= .5
DRIVE EFF. (GSR)>.2= 82
REGENERATION EFF.= 90

RESULTS:

VEHICLE SPEED (mph)	LATERAL ACCELERATION (g _s)	TURN RADIUS (ft)	INNER SPROCKET			OUTER SPROCKET		
			HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)	HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)
1.00	0.01	4.77	16.68	-5.27	-16624.15	4.86	37.11	687.73
2.50	0.09	4.44	54.12	-17.08	-16642.10	13.00	96.68	706.35
5.00	0.50	3.35	226.28	-71.16	-16702.05	33.72	230.36	768.70
7.50	0.50	7.54	-59.25	18.90	-16467.32	22.53	219.91	537.98
10.00	0.50	13.40	-257.74	83.83	-16149.08	10.07	234.58	225.35
15.00	0.50	30.15	-549.38	188.55	-15302.82	-33.29	289.06	-604.87
20.00	0.50	53.60	-762.19	280.72	-14260.26	-110.18	356.10	-1624.99
25.00	0.50	83.75	-919.60	367.86	-13129.57	-222.30	428.16	-2726.82
30.00	0.50	120.60	-1034.86	452.49	-12011.83	-364.63	502.74	-3809.30
35.00	0.50	164.15	-1120.58	535.68	-10986.82	-528.12	578.75	-4792.63
40.00	0.50	214.40	-1189.04	617.97	-10105.57	-702.31	655.66	-5625.78
45.00	0.50	271.35	-1250.89	699.67	-9389.87	-877.63	733.17	-6286.98

END

SPROCKET HORSEPOWER

CODE: #2TRTN

BY: W.E. RODLER
L.M. FERNANDEZ

REV. DATE: 91984
RUN DATE: 52985.10

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5
MAXIMUM VELOCITY, mph= 45
ENGINE GROSS HP= 500
LOSS ENGINE HP= 60
FRONTAL AREA, in= 57
COEFFICIENT OF DRAG= 1
TREAD WIDTH, in= 92.5
TRACK LENGTH, in= 150
TRACK PITCH, in= 6.03
NUMBER OF SPROCKET TEETH= 11
ROLLING RESISTANCE, lb per ton= 100
GRADE, %=-30
COEFFICIENT OF FRICTION= .7
MAXIMUM ACCELERATION, g= .5
DRIVE EFF. @SR>.2= 82
REGENERATION EFF.= 90

RESULTS:

VEHICLE SPEED (mph)	LATERAL ACCELERATION (g)	TURN RADIUS (ft)	INNER SPROCKET HORSEPOWER (hp)	INNER SPROCKET ROT. SPEED (rpm)	INNER SPROCKET TORQUE (lbft)	OUTER SPROCKET HORSEPOWER (hp)	OUTER SPROCKET ROT. SPEED (rpm)	OUTER SPROCKET TORQUE (lbft)
1.00	0.01	4.81	12.26	-5.06	-12724.82	32.19	36.90	4581.70
2.50	0.09	4.73	32.86	-13.56	-12729.08	81.36	93.16	4586.63
5.00	0.37	4.54	76.72	-31.63	-12738.60	167.09	190.83	4598.55
7.50	0.50	7.54	-45.23	18.90	-12570.67	185.68	219.91	4434.63
10.00	0.50	13.40	-195.55	83.83	-12252.43	184.11	234.58	4122.00
15.00	0.50	30.15	-409.49	188.55	-11406.18	181.17	289.06	3291.78
20.00	0.50	53.60	-553.92	280.72	-10363.61	154.02	356.10	2271.66
25.00	0.50	83.75	-646.68	367.86	-9232.92	95.37	428.16	1169.82
30.00	0.50	120.60	-699.15	452.49	-8115.18	8.36	502.74	87.35
35.00	0.50	164.15	-723.15	535.68	-7090.17	-98.73	578.75	-895.98
40.00	0.50	214.40	-730.55	617.97	-6208.92	-215.86	655.66	-1729.13
45.00	0.50	271.35	-731.79	699.67	-5493.22	-333.68	733.17	-2390.33

END

SPROCKET HORSEPOWER

CODE: #2TRTN

BY: W.E. RODLER
L.M. FERNANDEZ

REV. DATE: 91984
RUN DATE: 52985.09

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5
MAXIMUM VELOCITY, mph= 45
ENGINE GROSS HP= 500
LOSS ENGINE HP= 60
FRONTAL AREA, in= 57
COEFFICIENT OF DRAG= 1
TREAD WIDTH, in= 92.5
TRACK LENGTH, in= 150
TRACK PITCH, in= 6.03
NUMBER OF SPROCKET TEETH= 11
ROLLING RESISTANCE, lb per ton= 100
GRADE, %=-15
COEFFICIENT OF FRICTION= .7
MAXIMUM ACCELERATION, gs= .5
DRIVE EFF. @SR>.2= 82
REGENERATION EFF.= 90

RESULTS:

VEHICLE LATERAL SPEED ACCELERATION (mph)	TURN RADIUS (ft)	INNER SPROCKET		OUTER SPROCKET	
		HORSEPOWER (hp)	ROT. SPEED (rpm)	HORSEPOWER (hp)	ROT. SPEED (rpm)
1.00	0.01	9.71	-4.93	48.76	36.77
2.50	0.09	22.85	-11.61	120.90	91.21
5.00	0.31	27.95	-14.24	229.06	173.44
7.50	0.50	-36.65	18.90	285.53	219.91
10.00	0.50	-157.49	83.93	290.62	234.58
15.00	0.50	-323.88	188.55	312.41	289.06
20.00	0.50	-426.47	280.72	315.70	356.10
25.00	0.50	-479.66	367.86	289.77	428.16
30.00	0.50	-493.71	452.49	236.62	502.74
35.00	0.50	-479.93	535.68	164.04	578.75
40.00	0.50	-449.97	617.97	81.83	655.66
45.00	0.50	-414.12	699.67	-0.80	733.17

END

SPROCKET HORSEPOWER

CODE: #2TRTRN

BY: W.E. RODLER
L.M. FERNANDEZ

REV. DATE: 91984
RUN DATE: 52985.08

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5
MAXIMUM VELOCITY, mph= 45
ENGINE GROSS HP= 500
LOSS ENGINE HP= 40
FRONTAL AREA, in= 57
COEFFICIENT OF DRAG= 1
TREAD WIDTH, in= 92.5
TRACK LENGTH, in= 150
TRACK PITCH, in= 6.03
NUMBER OF SPROCKET TEETH= 11
ROLLING RESISTANCE, lb per ton= 100
REGENERATION EFF.= 90
GRADE, %=-5
COEFFICIENT OF FRICTION= .7
MAXIMUM ACCELERATION, gs= .5
DRIVE EFF. @SR>.2= 82

RESULTS:

VEHICLE LATERAL SPEED ACCELERATION (mph)	TURN RADIUS (ft)	INNER SPROCKET			OUTER SPROCKET		
		HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)	HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)
1.00	4.64	9.66	-5.85	-8661.95	62.19	37.70	8664.22
2.50	4.82	20.79	-12.62	-8651.65	151.97	92.22	8654.59
5.00	5.72	14.31	-8.74	-8600.39	275.18	167.94	8605.73
7.50	7.54	-30.58	18.90	-8497.97	356.21	219.91	8507.33
10.00	13.40	-130.55	83.83	-8179.73	366.01	234.58	8194.69
15.00	30.15	-263.28	188.55	-7333.48	405.32	289.06	7344.48
20.00	53.60	-336.24	280.72	-6290.91	430.15	356.10	6344.35
25.00	83.75	-361.42	367.86	-5160.23	427.38	428.16	5242.52
30.00	120.60	-348.27	452.49	-4042.49	398.21	502.74	4160.05
35.00	164.15	-307.76	535.68	-3017.48	350.06	578.75	3176.72
40.00	214.40	-251.35	617.97	-2136.23	292.57	655.66	2343.56
45.00	271.35	-189.24	699.67	-1420.53	234.85	733.17	1682.37

END

SPROCKET HORSEPOWER

CODE: #2TRTRN

BY: W.E. RODLER
L.M. FERNANDEZ

REV. DATE: 91984
RUN DATE: 52985.07

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5
MAXIMUM VELOCITY, mph= 45
ENGINE GROSS HP= 500
LOSS ENGINE HP= 40
FRONTAL AREA, in= 57
COEFFICIENT OF DRAG= 1

TREAD WIDTH, in= 92.5
TRACK LENGTH, in= 150
TRACK PITCH, in= 6.03
NUMBER OF SPROCKET TEETH= 11
ROLLING RESISTANCE, lb per ton= 100
REGENERATION EFF.= 90

GRADE, %=-2
COEFFICIENT OF FRICTION=.7
MAXIMUM ACCELERATION, gs=.5
DRIVE EFF. @SR>.2= 82

RESULTS:

VEHICLE LATERAL SPEED ACCELERATION (mph)	TURN RADIUS (ft)	INNER SPROCKET		OUTER SPROCKET	
		HORSEPOWER (hp)	TORQUE (lbft)	HORSEPOWER (hp)	TORQUE (lbft)
1.00	4.64	9.04	-8147.97	65.82	9177.52
2.50	5.06	15.68	-8124.66	156.42	9154.86
5.00	6.04	6.17	-8068.87	282.85	9101.48
7.50	7.59	-29.69	-7981.70	376.51	9018.33
10.00	13.40	-122.35	-7666.09	388.95	8708.33
15.00	30.15	-244.84	-6819.84	433.59	7878.11
20.00	53.60	-308.79	-5777.27	464.98	6857.99
25.00	83.75	-325.45	-4646.59	469.25	5756.16
30.00	120.60	-304.02	-3528.85	447.37	4673.69
35.00	164.15	-255.37	-2503.84	406.66	3690.36
40.00	214.40	-190.92	-1622.59	356.69	2857.20
45.00	271.35	-120.81	-906.89	306.55	2196.01

END

SPROCKET HORSEPOWER

CODE:#2TRTN

BY:W.E. RODLER
L.M. FERNANDEZ

REV. DATE: 91984
RUN DATE:52985.06

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5
MAXIMUM VELOCITY ,mph= 45
ENGINE GROSS HP= 500
LOSS ENGINE HP= 40
FRONTAL AREA ,in= 57
COEFFICIENT OF DRAG= 1
TREAD WIDTH,in= 92.5
TRACK LENGTH,in= 150
TRACK PITCH,in= 6.03
NUMBER OF SPROCKET TEETH= 11
ROLLING RESISTANCE,lb per ton= 100
GRADE,%= 0
COEFFICIENT OF FRICTION= .7
MAXIMUM ACCELERATION ,gs= .5
DRIVE EFF. @SR>.2= 82
REGENERATION EFF.= 90

RESULTS:

VEHICLE SPEED (mph)	LATERAL ACCELERATION (gs)	TURN RADIUS (ft)	INNER SPROCKET			OUTER SPROCKET		
			HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)	HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)
1.00	0.01	5.02	6.23	-4.21	-7784.08	65.20	36.05	9499.67
2.50	0.08	5.20	12.94	-8.74	-7773.54	159.62	88.34	9489.80
5.00	0.27	6.25	1.69	-1.15	-7713.93	287.99	160.35	9432.63
7.50	0.47	7.95	-34.97	24.11	-7618.74	381.86	214.70	9341.42
10.00	0.50	13.40	-116.88	83.83	-7323.07	404.27	234.58	9051.36
15.00	0.50	30.15	-232.52	188.55	-6476.82	452.46	289.06	8221.14
20.00	0.50	53.60	-290.45	280.72	-5434.25	488.24	356.10	7201.02
25.00	0.50	83.75	-301.42	367.86	-4303.56	497.22	428.16	6099.18
30.00	0.50	120.60	-274.47	452.49	-3185.82	480.21	502.74	5016.71
35.00	0.50	164.15	-220.39	535.68	-2160.81	444.45	578.75	4033.38
40.00	0.50	214.40	-150.56	617.97	-1279.56	399.51	655.66	3200.23
45.00	0.50	271.35	-75.12	699.67	-563.86	354.44	733.17	2539.03

END

SPROCKET HORSEPOWER

CODE: #2TRTN

BY: W.E. RODLER
L.M. FERNANDEZ

REV. DATE: 91984
RUN DATE: 52985.04

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5
MAXIMUM VELOCITY, mph= 45
ENGINE GROSS HP= 500
LOSS ENGINE HP= 60
FRONTAL AREA, in= 57
COEFFICIENT OF DRAG= 1
TREAD WIDTH, in= 92.5
TRACK LENGTH, in= 150
TRACK PITCH, in= 6.03
NUMBER OF SPROCKET TEETH= 11
ROLLING RESISTANCE, lb per ton= 100
REGENERATION EFF.= 90
GRADE, %= 2
COEFFICIENT OF FRICTION= .7
MAXIMUM ACCELERATION, gs= .5
DRIVE EFF. @SR>.2= 82

RESULTS:

VEHICLE LATERAL SPEED ACCELERATION (mph)	TURN RADIUS (ft)	INNER SPROCKET		OUTER SPROCKET				
		HORSEPOWER (hp)	ROT. SPEED (rpm)	HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)		
1.00	0.01	5.44	3.73	-2.64	-7417.55	64.47	34.48	9819.20
2.50	0.07	5.62	7.22	-5.12	-7407.22	158.24	84.72	9809.54
5.00	0.24	6.86	-8.42	6.03	-7337.28	284.13	153.18	9742.01
7.50	0.43	8.81	-45.96	33.39	-7228.92	376.93	205.41	9637.65
10.00	0.50	13.40	-111.40	83.83	-6980.04	419.60	234.58	9394.38
15.00	0.50	30.15	-220.21	188.55	-6133.79	471.34	289.06	8564.16
20.00	0.50	53.60	-272.12	280.72	-5091.22	511.49	356.10	7544.04
25.00	0.50	83.75	-277.40	367.86	-3960.54	525.18	428.16	6442.21
30.00	0.50	120.60	-244.92	452.49	-2842.80	513.04	502.74	5359.74
35.00	0.50	164.15	-185.40	535.68	-1817.79	482.25	578.75	4376.41
40.00	0.50	214.40	-110.19	617.97	-936.54	442.33	655.66	3543.25

SPROCKET HORSEPOWER

CODE: #2TRTN

BY: W.E. RODLER
L.M. FERNANDEZ

REV. DATE: 91984
RUN DATE: 52985.03

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5
MAXIMUM VELOCITY, mph= 45
ENGINE GROSS HP= 500
LOSS ENGINE HP= 60
FRONTAL AREA, in= 57
COEFFICIENT OF DRAG= 1
TREAD WIDTH, in= 92.5
TRACK LENGTH, in= 150
TRACK PITCH, in= 6.03
NUMBER OF SPROCKET TEETH= 11
ROLLING RESISTANCE, lb per ton= 100
GRADE, %= 5
COEFFICIENT OF FRICTION= .7
MAXIMUM ACCELERATION, gs= .5
DRIVE EFF. @SR>.2= 82
REGENERATION EFF.= 90

RESULTS:

VEHICLE SPEED (mph)	LATERAL ACCELERATION (gs)	TURN RADIUS (ft)	INNER SPROCKET HORSEPOWER (hp)	INNER SPROCKET ROT. SPEED (rpm)	INNER SPROCKET TORQUE (lbft)	OUTER SPROCKET HORSEPOWER (hp)	OUTER SPROCKET ROT. SPEED (rpm)	OUTER SPROCKET TORQUE (lbft)
1.00	0.01	5.68	2.45	-1.87	-6890.78	66.24	33.71	10319.70
2.50	0.07	5.98	3.20	-2.45	-6873.85	160.96	82.05	10303.44
5.00	0.23	7.30	-13.55	10.47	-6799.41	289.75	148.74	10231.41
7.50	0.39	9.55	-50.98	40.12	-6674.76	382.50	198.69	10110.77
10.00	0.49	13.60	-104.38	84.92	-6456.02	440.02	233.49	9897.64
15.00	0.50	30.15	-201.77	182.55	-5620.15	499.61	289.06	9077.80
20.00	0.50	53.60	-244.67	280.72	-4577.59	546.32	356.10	8057.68
25.00	0.48	87.16	-234.25	369.04	-3333.84	556.30	426.98	6842.79
30.00	0.31	194.25	-68.50	462.01	-778.65	405.95	493.21	4322.86

SPROCKET HORSEPOWER

CODE:#2TRTN

BY:W.E. RODLER

REV. DATE: 91984

L.M. FERNANDEZ

RUN DATE:52985.01

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5
MAXIMUM VELOCITY , mph= 45
ENGINE GROSS HP= 500
LOSS ENGINE HP= 60
FRONTAL AREA , in= 57
COEFFICIENT OF DRAG= 1
TREAD WIDTH, in= 92.5
TRACK LENGTH, in= 150
TRACK PITCH, in= 6.03
NUMBER OF SPROCKET TEETH= 11
ROLLING RESISTANCE, lb per ton= 100
GRADE, %= 15
COEFFICIENT OF FRICTION= .7
MAXIMUM ACCELERATION , gs= .5
DRIVE EFF. @SR>.2= 82
REGENERATION EFF.= 90

RESULTS:

VEHICLE SPEED (mph)	LATERAL ACCELERATION (gs)	TURN RADIUS (ft)	INNER SPROCKET		OUTER SPROCKET			
			HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)	HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)
1.00	0.01	6.47	-0.30	0.31	-5158.84	71.83	31.53	11963.90
2.50	0.06	7.27	-4.94	5.08	-5114.34	169.14	74.52	11920.07
5.00	0.18	9.35	-24.38	25.61	-4999.53	300.33	133.59	11807.67
7.50	0.28	13.37	-57.12	62.72	-4782.95	388.74	176.08	11595.10
10.00	0.29	22.75	-93.98	114.80	-4299.46	430.98	203.61	11117.22
15.00	0.15	97.57	-57.01	223.28	-1341.11	395.87	254.34	8174.90

SPROCKET HORSEPOWER

CODE:#2TRN BY:W.E. RODLER REV.DATE: 91984
L.M. FERNANDEZ RUN DATE:52985.02

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5 TREAD WIDTH, in= 92.5 GRADE, % = 30
MAXIMUM VELOCITY, mph= 45 TRACK LENGTH, in= 150 COEFFICIENT OF FRICTION= .7
ENGINE GROSS HP= 500 TRACK PITCH, in= 6.03 MAXIMUM ACCELERATION, gs= .5
LOSS ENGINE HP= 60 NUMBER OF SPROCKET TEETH= 11 DRIVE EFF. @SR>.2= 82
FRONTAL AREA, in= 57 ROLLING RESISTANCE, lb per ton= 100 REGENERATION EFF.= 90
COEFFICIENT OF DRAG= 1

RESULTS:

VEHICLE LATERAL SPEED ACCELERATION (mph)	TURN RADIUS (ft)	INNER SPROCKET		OUTER SPROCKET	
		HORSEPOWER (hp)	ROT. SPEED (rpm)	HORSEPOWER (hp)	ROT. SPEED (rpm)
1.00	9.23	-2.49	4.98	72.61	26.86
2.50	10.34	-7.51	15.38	172.87	64.22
5.00	15.38	-20.43	46.77	296.97	112.44
7.50	30.10	-28.00	94.24	361.74	144.57
10.00	231.58	111.69	154.84	242.87	163.57

SPROCKET HORSEPOWER

CODE: #2TRTN

BY: W.E. RODLER
L.M. FERNANDEZ

REV. DATE: 91984
RUN DATE: 52985.05

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5
MAXIMUM VELOCITY, mph= 45
ENGINE GROSS HP= 500
LOSS ENGINE HP= 60
FRONTAL AREA, in= 57
COEFFICIENT OF DRAG= 1

TREAD WIDTH, in= 92.5
TRACK LENGTH, in= 150
TRACK PITCH, in= 6.03
NUMBER OF SPROCKET TEETH= 11
ROLLING RESISTANCE, lb per ton= 100

GRADE, %= 60
COEFFICIENT OF FRICTION= .7
MAXIMUM ACCELERATION, gs= .5
DRIVE EFF. @SR>.2= 82
REGENERATION EFF.= 90

RESULTS:

VEHICLE LATERAL SPEED ACCELERATION (mph)	TURN RADIUS (ft)	INNER SPROCKET		OUTER SPROCKET				
		HORSEPOWER (hp)	ROT. SPEED (rpm)	HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)		
1.00	0.00	21.05	4.00	11.12	1890.67	68.94	20.72	17476.94
2.50	0.01	36.55	16.49	32.89	2632.33	148.84	46.71	16735.96

B.5 Downhill Steering Limit

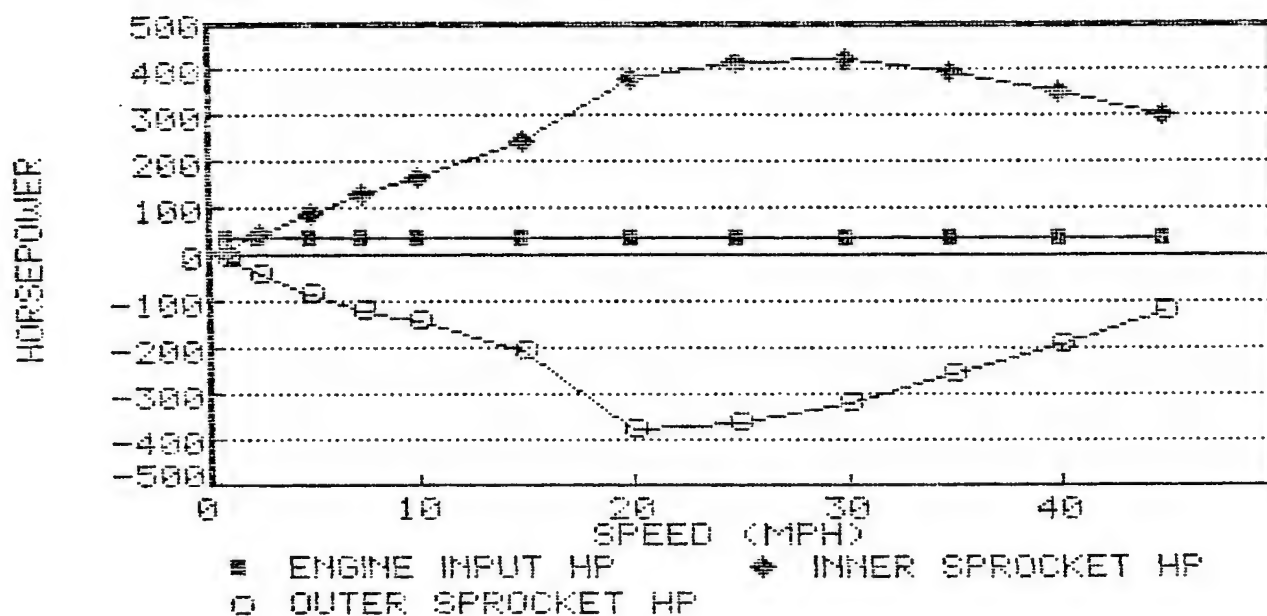
Limited available power while coasting downhill can limit steering control. When operating on moderate downgrades, the engine can at times be operating near idle condition. Steering reactions can then be limited by power available. This condition is encountered with mechanically driven tracked vehicles and it is necessary for the driver to give the engine added throttle to obtain normal steering response. Since it is instinctive to turn and apply brakes to avoid an obstacle, special driver training is required to assure proper response. The results of the studies on this subject are shown on the following curves and their data sheets.

1. Figure B.5-1: These curves show a typical power distribution for maximum turn going down a moderate grade.
2. Figure B.5-2: These curves replot the same data as Figure B.5-1, but a summation curve "Engine + Both Sprockets" is shown. At points near 20 MPH the net power barely covers system losses.
3. Figure B.5-3: These curves show that below 20 MPH decreased net engine power degrades steering ability.
4. Figure B.5-4 and B.5-5: These curves plot the same data with different scales for better legibility. They show that steering ability is limited up to 25 MPH.

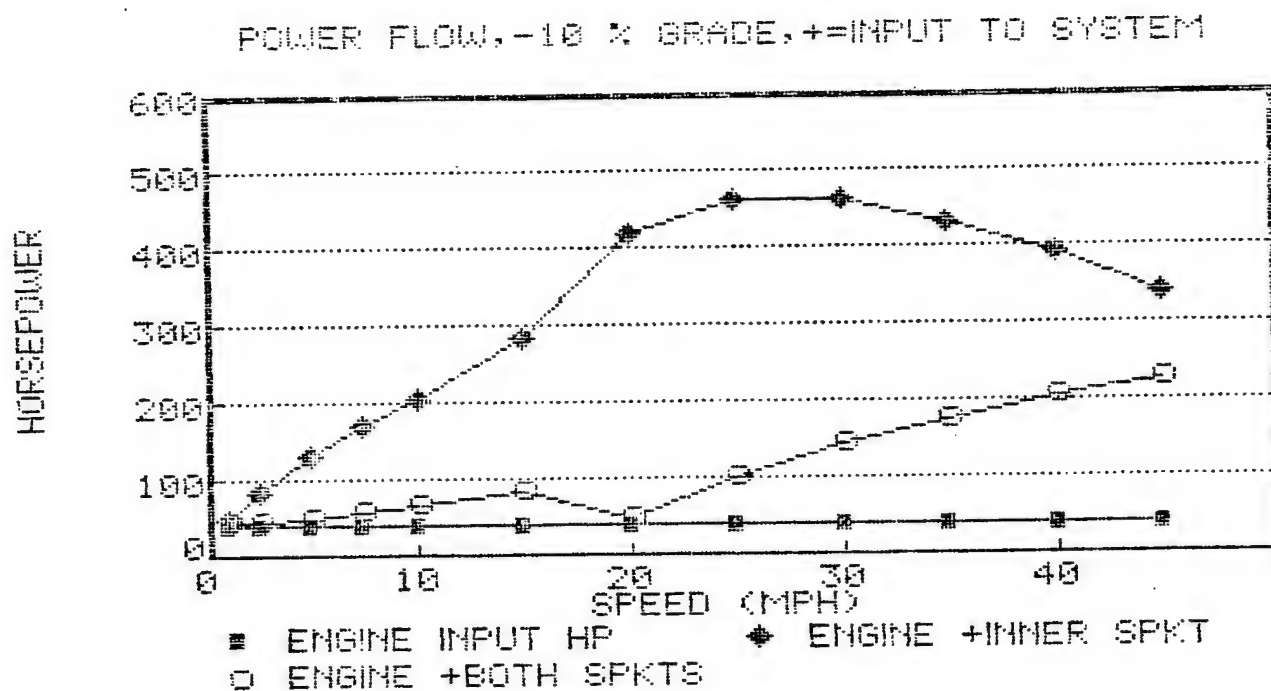
Acceleration analysis was made for the 60% grade starts and the results are shown in Figures 5.2.6.4-1. These curves show positive starts that promptly reach grade limited speed.

X Data	ENGINE INPUT HP	INNER SPROCKET HP	OUTER SPROCKET HP
1	40	9.94	-5.29
2.50	40	46.46	-42.85
5	40	92	-83.80
7.50	40	132.80	-116.02
10	40	167.29	-138.97
15	40	245.55	-201.24
20	40	381.67	-372.48
25	40	420.95	-355.04
30	40	421.51	-316.79
35	40	394.47	-256.34
40	40	351.38	-186.40
45	40	302.50	-116.14

POWER FLOW, -10 % GRADE, +=INPUT TO SYSTEM



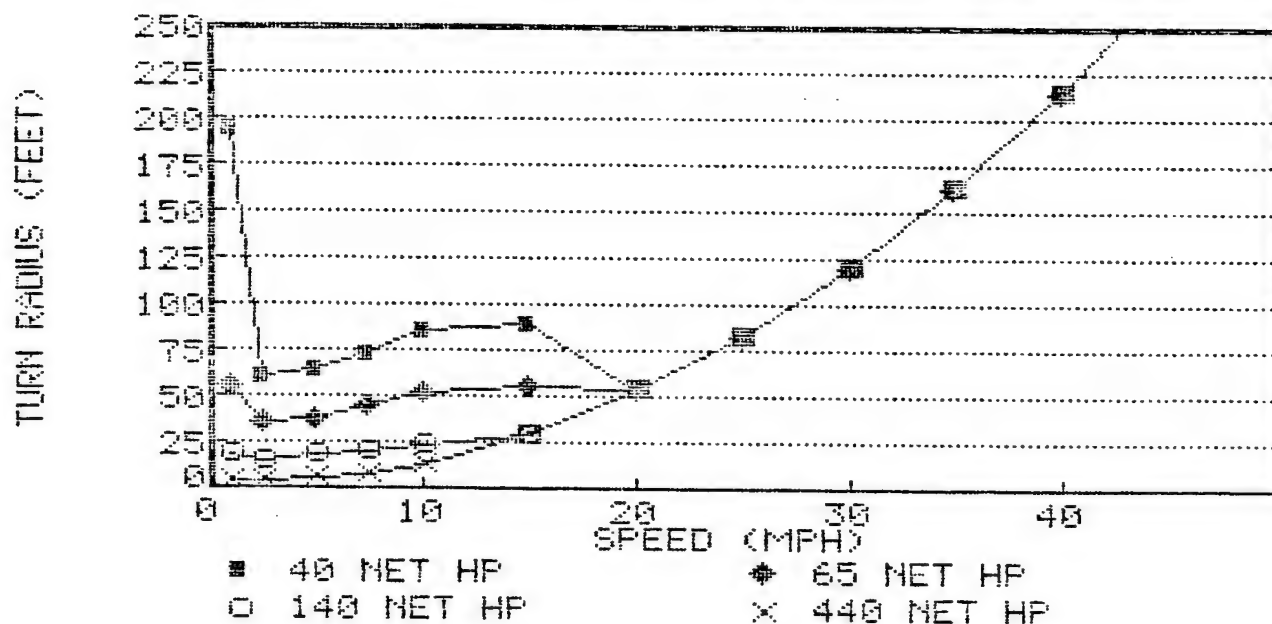
X Data	ENGINE INPUT HP	ENGINE +INNER SPKT	ENGINE +BOTH SPKTS
1	40	9.94	-5.29
2.50	40	46.46	-42.85
5	40	92	-83.80
7.50	40	132.80	-116.02
10	40	167.29	-138.97
15	40	245.55	-201.24
20	40	381.67	-372.48
25	40	420.95	-358.04
30	40	421.51	-316.79
35	40	394.47	-256.34
40	40	351.38	-186.40
45	40	302.50	-116.14



X Data 40 NET HP 65 NET HP 140 NET HP 440 NET HP

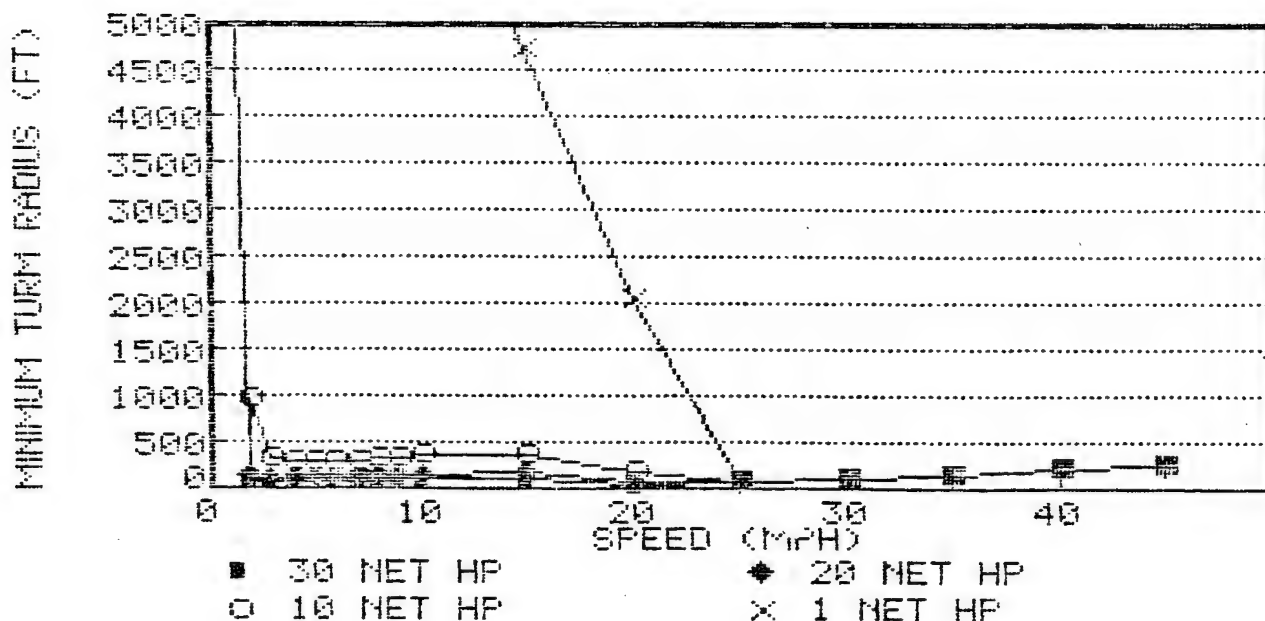
1	194.88	56.54	18.07	4.85
2.50	62.12	36.16	16.04	4.97
5	64.65	39.02	17.97	5.68
7.50	73.82	45.09	20.80	7.54
10	86.38	52.89	24.45	13.40
15	90.75	55.72	30.15	30.15
20	53.60	53.60	53.60	53.60
25	83.75	83.75	83.75	83.75
30	120.60	120.60	120.60	120.60
35	164.15	164.15	164.15	164.15
40	214.40	214.40	214.40	214.40
45	271.35	271.35	271.35	271.35

LIMITED PART THROTTLE DOWNHILL STEERING



X Data	30 NET HP	20 NET HP	10 NET HP	1 NET HP
1	9108.08			
2	95.08	173.44	986.73	
3	84.55	136.40	352.76	
4	84.59	132.11	301.45	
5	87.33	134.50	292.54	
6	91.34	139.66	296.52	
7	96.28	146.57	306.86	19534.49
8	102.11	155.01	321.68	9943.98
9	108.97	165.11	340.61	7847.88
10	115.67	175.01	359.44	6962.97
15	121.24	182.60	369.69	4746.54
20	63.59	95.49	191.67	2048.84
25	83.75	83.75	83.75	83.75
30	120.60	120.60	120.60	120.60
35	164.15	164.15	164.15	164.15
40	214.40	214.40	214.40	214.40
45	271.35	271.35	271.35	271.35

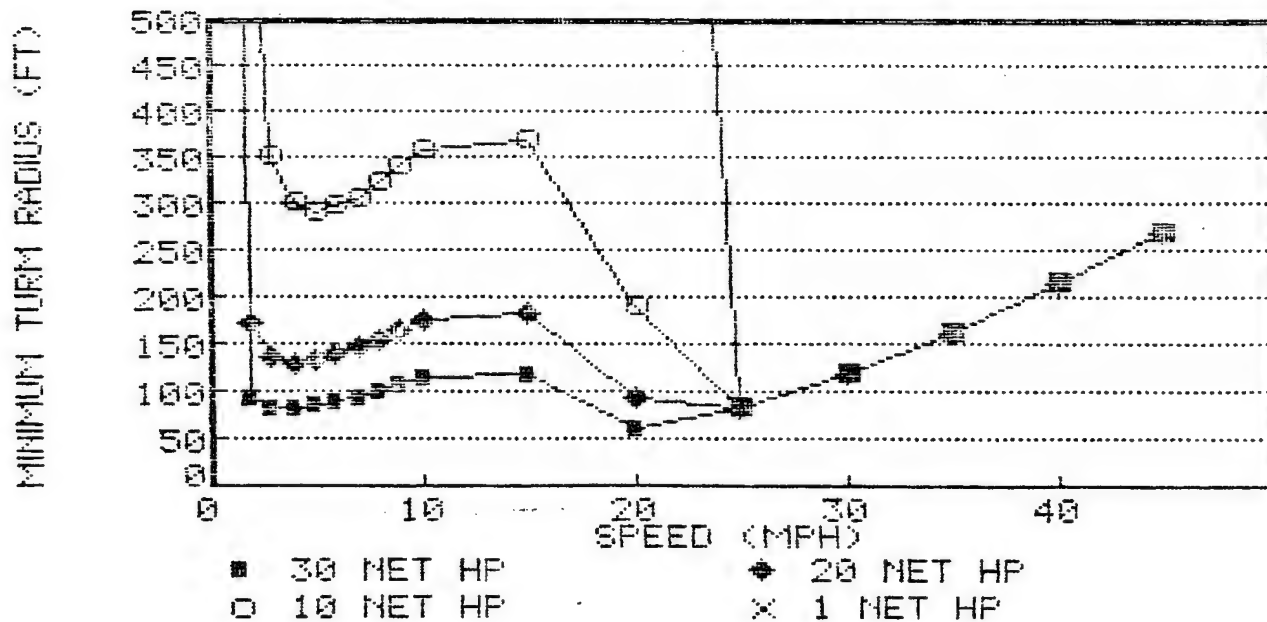
PART THROTTLE DOWNHILL STEERING LIMITS



X Data 30 NET HP 20 NET HP 10 NET HP 1 NET HP

1	9108.08			
2	95.08	173.44	986.73	
3	84.55	136.40	352.76	
4	84.59	132.11	301.45	
5	87.33	134.50	292.54	
6	91.34	139.66	296.52	
7	96.28	146.57	306.86	19534.49
8	102.11	155.01	321.68	9943.98
9	108.97	165.11	340.61	7847.88
10	115.67	175.01	359.44	6962.97
15	121.24	182.60	369.69	4746.54
20	63.59	95.49	191.67	2048.84
25	83.75	83.75	83.75	83.75
30	120.60	120.60	120.60	120.60
35	164.15	164.15	164.15	164.15
40	214.40	214.40	214.40	214.40
45	271.35	271.35	271.35	271.35

PART THROTTLE DOWNHILL STEERING LIMITS



SPROCKET HORSEPOWER

CODE:#2TRRN BY:W.E. RODLER REV. DATE: 91984
L.M. FERNANDEZ RUN DATE:60385.01

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5 TREAD WIDTH, in= 92.51999 GRADE, %=-10
MAXIMUM VELOCITY , mph= 45 TRACK LENGTH, in= 150 COEFFICIENT OF FRICTION= .7
ENGINE GROSS HP= 125 TRACK PITCH, in= 6.03 MAXIMUM ACCELERATION , gs= .5
LOSS ENGINE HP= 60 NUMBER OF SPROCKET TEETH= 11 DRIVE EFF. @SK>.2= 82
FRONTAL AREA , in= 57 ROLLING RESISTANCE, lb per ton= 100 REGENERATION EFF.= 90
COEFFICIENT OF DRAG= 1

RESULTS:

VEHICLE SPEED (mph)	LATERAL ACCELERATION (gs)	TURN RADIUS (ft)	INNER SPROCKET		OUTER SPROCKET	
			HORSEPOWER (hp)	ROT. SPEED (rpm)	HORSEPOWER (hp)	ROT. SPEED (rpm)
1.00	0.00	56.54	-18.97	14.13	18.03	17.71
5.00	0.01	36.16	-49.47	32.82	55.41	46.79
10.00	0.04	39.20	-98.82	66.72	107.14	92.49
15.00	0.08	45.09	-146.89	102.60	151.14	136.21
20.00	0.13	52.89	-191.77	140.11	186.83	178.30
25.00	0.27	55.72	-284.71	211.61	273.33	266.00
30.00	0.50	53.60	-381.67	280.72	372.48	356.10
35.00	0.50	83.75	-420.95	367.86	358.04	428.16
40.00	0.50	120.60	-421.51	452.48	316.79	502.74
45.00	0.50	164.15	-394.46	535.68	256.34	578.75
50.00	0.50	214.40	-351.38	617.97	186.40	655.66
55.00	0.50	271.35	-302.50	699.67	116.14	733.17
60.00	0.50					831.99

SPROCKET HORSEPOWER

CODE: #2TRTRN REV. DATE: 91984
BY: W.E. KOOLER RUN DATE: 60385.02
L.M. FERNANDEZ

DATA INPUT: *****

GROSS VEHICLE WEIGHT, tons= 19.5 TREAD WIDTH, in= 92.51999 GRADE, %=-10
MAXIMUM VELOCITY, mph= 45 TRACK LENGTH, in= 150 COEFFICIENT OF FRICTION= .7
ENGINE GROSS HP= 100 TRACK PITCH, in= 6.03 MAXIMUM ACCELERATION, g=.5
LOSS ENGINE HP= 60 NUMBER OF SPROCKET TEETH= 11 DRIVE EFF. @SR>.2= 82
FRONTAL AREA, in= 57 ROLLING RESISTANCE, lb per ton= 100 REGENERATION EFF.= 90
COEFFICIENT OF DRAG= 1

RESULTS: *****

VEHICLE SPEED (mph)	LATERAL ACCELERATION (gs)	TURN RADIUS (ft)	INNER SPROCKET		OUTER SPROCKET	
			HORSEPOWER (hp)	ROT. SPEED (rpm)	HORSEPOWER (hp)	ROT. SPEED (rpm)
1.00	0.00	194.88	-9.94	15.40	5.29	16.44
2.50	0.01	162.12	-46.46	35.74	42.85	43.87
B-120	0.03	64.65	-92.00	71.79	83.80	87.41
	0.05	73.82	-132.80	109.14	116.02	129.67
10.00	0.08	86.38	-167.29	147.51	138.97	170.90
15.00	0.17	90.75	-245.55	222.11	201.24	255.50
20.00	0.50	53.60	-381.67	280.72	372.48	356.10
25.00	0.50	83.75	-420.95	367.86	358.04	428.16
30.00	0.50	120.60	-421.51	452.48	316.79	502.74
35.00	0.50	164.15	-394.47	535.68	256.34	578.75
40.00	0.50	214.40	-351.38	617.97	186.40	655.66
45.00	0.50	271.35	-302.50	699.67	116.14	733.17



SPROCKET HORSEPOWER

CODE:#21TRN

BY:W.E. RODLER

L.M. FERNANDEZ

REV. DATE: 91984

RUN DATE:60385.04

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5
 MAXIMUM VELOCITY , mph= 45
 ENGINE GROSS HP= 90
 LOSS ENGINE HP= 60
 FRONTAL AREA , in= 57
 COEFFICIENT OF DRAG= 1
 TREAD WIDTH, in= 92.51999
 TRACK LENGTH, in= 150
 TRACK PITCH, in= 6.03
 NUMBER OF SPROCKET TEETH= 11
 ROLLING RESISTANCE, lb per ton= 100
 GRADE, %=-10
 COEFFICIENT OF FRICTION= .7
 MAXIMUM ACCELERATION , g=.5
 DRIVE EFF. @SR>.2= 82
 REGENERATION EFF.= 90

RESULTS:

VEHICLE SPEED (mph)	LATERAL ACCELERATION (g)	TURN RADIUS (ft)	INNER SPROCKET		OUTER SPROCKET			
			HORSEPOWER (hp)	ROT. SPEED (rpm)	HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)	
1.00	0.00	9108.08	-2.57	15.91	-849.16	-2.58	15.93	-849.16
2.50	0.00	87.14	-41.72	36.90	-5937.38	34.47	42.70	4239.74
	0.02	87.33	-83.35	73.82	-5930.15	68.85	85.39	4234.92
	0.04	99.08	-118.25	111.76	-5557.25	93.52	127.05	3866.02
10.00	0.06	115.67	-145.44	150.47	-5076.39	108.42	167.94	3390.78
15.00	0.12	121.24	-211.95	226.31	-4918.88	155.47	251.30	3249.30
20.00	0.42	63.59	-368.21	286.63	-6746.88	340.02	350.18	5099.74
25.00	0.50	83.75	-420.95	367.86	-6010.21	358.04	428.16	4391.93
30.00	0.50	120.60	-421.51	452.48	-4892.54	316.79	502.74	3309.52
35.00	0.50	164.15	-394.47	535.68	-3867.59	256.34	578.75	2326.25
40.00	0.50	214.40	-351.38	617.97	-2986.39	186.40	655.66	1493.14
45.00	0.50	271.35	-302.50	699.67	-2270.73	116.14	733.17	831.99

SPROCKET HORSEPOWER

CODE:#2TRTN

BY:W.E. RUDLER

L.M. FERNANDEZ

REV.DATE: 91984

RUN DATE:60385.05

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5
 MAXIMUM VELOCITY ,mph= 45
 ENGINE GROSS HP= 200
 LOSS ENGINE HP= 60
 FRONTAL AREA ,in= 57
 COEFFICIENT OF DRAG= 1
 TREAD WIDTH,in= 92.51999
 TRACK LENGTH,in= 150
 TRACK PITCH,in= 6.03
 NUMBER OF SPROCKET TEETH= 11
 ROLLING RESISTANCE,lb per ton= 100 REGENERATION EFF.= 90
 GRADE,%=-10
 COEFFICIENT OF FRICTION= .7
 MAXIMUM ACCELERATION ,gs= .5
 DRIVE EFF. @SR>.2= 82

RESULTS:

VEHICLE SPEED (mph)	LATERAL ACCELERATION (gs)	TURN RADIUS (ft)	INNER SPROCKET		OUTER SPROCKET			
			HORSEPOWER (hp)	ROT. SPEED (rpm)	HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)	
1.00	0.00	18.07	-17.29	10.33	-8793.15	29.06	21.51	7094.84
2.50	0.03	16.04	-40.76	24.06	-8897.13	76.13	55.54	7199.49
	0.09	17.97	-86.26	51.50	-8796.37	145.62	107.70	7101.13
	0.18	20.80	-136.68	82.98	-8650.86	206.49	155.83	6959.63
10.00	0.27	24.45	-190.04	117.89	-8466.32	258.87	200.51	6780.71
15.00	0.50	30.15	-293.78	188.55	-8183.34	358.50	289.06	6513.76
20.00	0.50	53.60	-381.67	280.72	-7140.83	372.48	356.10	5493.69
25.00	0.50	83.75	-420.95	367.86	-6010.21	358.04	428.16	4391.93
30.00	0.50	120.60	-421.51	452.48	-4892.54	316.79	502.74	3309.52
35.00	0.50	164.15	-394.47	535.68	-3867.59	256.34	578.75	2326.25
40.00	0.50	214.40	-351.38	617.97	-2986.39	186.40	655.66	1493.14
45.00	0.50	271.35	-302.50	699.67	-2270.77	116.14	733.17	831.99

SPROCKET HORSEPOWER

CODE:#2TRTN

BY:W.E. RODLER
L.M. FERNANDEZ

REV. DATE: 91984
RUN DATE:60385.06

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5
MAXIMUM VELOCITY ,mph= 45
ENGINE GROSS HP= 300
LOSS ENGINE HP= 60
FRONTAL AREA ,in= 57
COEFFICIENT OF DRAG= 1
TREAD WIDTH,in= 92.51999
TRACK LENGTH,in= 150
TRACK PITCH,in= 6.03
NUMBER OF SPROCKET TEETH= 11
ROLLING RESISTANCE,lb per ton= 100
GRADE,%=-10
COEFFICIENT OF FRICTION=.7
MAXIMUM ACCELERATION ,gs=.5
DRIVE EFF. @SK>.2= 82
REGENERATION EFF.= 90

RESULTS:

VEHICLE SPEED (mph)	LATERAL ACCELERATION (gs)	TURN RADIUS (ft)	INNER SPROCKET		OUTER SPROCKET	
			HORSEPOWER (hp)	ROT. SPEED (rpm)	HORSEPOWER (hp)	ROT. SPEED (rpm)
1.00	0.01	9.47	-9.25	5.26	38.20	26.58
2.50	0.05	9.21	-21.84	12.39	96.78	67.22
5.00	0.16	10.44	-54.63	31.22	182.69	127.99
7.50	0.31	12.11	-98.46	56.82	256.75	181.99
10.00	0.47	14.24	-151.03	88.28	319.84	230.13
15.00	0.50	30.15	-293.78	188.55	358.50	289.06
20.00	0.50	53.60	-381.67	280.72	372.48	356.10
25.00	0.50	83.75	-420.95	367.86	358.04	428.16
30.00	0.50	120.60	-421.51	452.48	316.79	502.74
35.00	0.50	164.15	-394.47	535.68	256.34	578.75
40.00	0.50	214.40	-351.38	617.97	186.40	655.66
45.00	0.50	271.35	-302.50	699.67	116.14	735.17
						831.99

SPROCKET HORSEPOWER

CODE:#21TRN

BY:W.E. RODLER

L.M. FERNANDEZ

REV.DATE: 91984

RUN DATE:60385.08

DATA INPUT:

GROSS VEHICLE WEIGHT, tons= 19.5
 MAXIMUM VELOCITY ,mph= 45
 ENGINE GROSS HP= 500
 LOSS ENGINE HP= 60
 FRONTAL AREA ,in= 57
 COEFFICIENT OF DRAG= 1
 TREAD WIDTH,in= 92.51999
 TRACK LENGTH,in= 150
 TRACK PITCH,in= 6.03
 NUMBER OF SPROCKET TEETH= 11
 ROLLING RESISTANCE,lb per ton= 100
 GRADE,%=-10
 COEFFICIENT OF FRICTION= .7
 MAXIMUM ACCELERATION ,gs= .5
 DRIVE EFF. @SR>.2= 82
 REGENERATION EFF.= 90

RESULTS:

VEHICLE SPEED (mph)	LATERAL ACCELERATION (gs)	TURN RADIUS (ft)	INNER SPROCKET		OUTER SPROCKET			
			HORSEPOWER (hp)	ROT. SPEED (rpm)	HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)	
1.00	0.01	4.85	8.84	-4.89	-9499.69	54.56	36.73	7801.38
2.50	0.08	4.97	19.81	-10.96	-9492.64	134.41	90.56	7795.00
5.00	0.29	5.68	16.84	-9.36	-9452.36	248.96	168.56	7757.12
10.00	0.50	7.54	-33.62	18.89	-9347.76	320.59	219.92	7656.54
15.00	0.50	13.40	-144.10	83.82	-9029.54	328.02	234.59	7343.92
20.00	0.50	30.15	-293.78	188.55	-8183.34	358.50	289.06	6513.76
25.00	0.50	53.60	-381.67	280.72	-7140.83	372.48	356.10	5493.69
30.00	0.50	83.75	-420.95	367.86	-6010.21	358.04	428.16	4391.93
35.00	0.50	120.60	-421.51	452.48	-4892.54	316.79	502.74	3309.52
40.00	0.50	164.15	-394.46	535.68	-3867.58	256.34	578.75	2326.25
45.00	0.50	214.40	-351.38	617.97	-2986.39	186.40	655.66	1493.14
50.00	0.50	271.35	-302.50	699.67	-2270.73	116.14	733.17	831.99

END

***** GEAR-PROCKET FRICTION-POWER BY W.E. KUDLER L.M. FERNANDEZ REV. DATE: 6/3/85 RUN DATE: 60305.10 CODE: #31RTN *****

***** DATA INPUT *****

GROSS VEHICLE WEIGHT, tons= 19.5
 MAXIMUM VELOCITY, mph= 45
 LNSINE GROSS HP= 90
 LOSS ENGINE HP= 60
 FRONTAL AREA, sq ft= 57
 COEFFICIENT OF DRAG= 1
 TREAD WIDTH, in= 92.51999
 TRACK LENGTH, in= 150
 TRACK PITCH, in= 6.03
 NUMBER OF SPROCKET TEETH= 11
 ROLLING RESISTANCE, lb per ton= 100
 REGENERATION EFF.= 90
 GRADE, %= 10
 COEFFICIENT OF FRICTION= .7
 MAXIMUM ACCELERATION, g= .5
 DRIVE EFF. @SR>.2= B2

***** RESULTS *****

VEHICLE LATERAL SPEED ACCELERATION (g)	TURN RADIUS (ft)	INNER SPROCKET			OUTER SPROCKET		
		HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbf ft)	HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbf ft)
45.00	271.35	-302.50	699.67	-2270.73	116.14	735.17	831.99
40.00	214.40	-351.30	617.97	-2906.39	186.40	685.66	1493.14
35.00	164.15	-394.47	535.60	-3067.59	256.34	570.75	2326.25
30.00	120.60	-421.51	452.40	-4092.54	316.79	502.74	3309.52
25.00	83.75	-420.95	367.86	-6010.21	358.04	428.16	4391.93
20.00	63.59	-368.21	286.63	-6746.88	340.02	350.10	5099.74
15.00	121.24	-211.95	226.31	-4918.88	155.47	251.50	3249.50
10.00	115.67	-145.44	150.47	-5076.39	108.42	167.94	3390.70
9.00	108.97	-135.26	134.94	-5264.50	103.25	151.63	3576.45
8.00	102.11	-124.30	119.45	-5465.50	97.24	135.20	3775.27
7.00	96.20	-111.86	104.10	-5643.54	89.37	110.79	3951.59
6.00	91.34	-98.15	88.09	-5799.63	79.86	102.16	4105.80
5.00	87.33	-83.35	73.82	-5930.15	68.85	85.59	4234.92
4.00	84.59	-67.53	58.91	-6021.08	56.37	68.46	4324.69
3.00	84.55	-50.66	44.18	-6023.07	42.29	51.55	4325.78
2.00	95.00	-32.16	29.72	-5683.72	25.78	33.97	3985.79
1.00	9108.08	-2.57	15.91	-8497.16	-2.58	15.93	-8497.16

 END

CODE#31313131

SPROCKET HORSEPOWER

BY W.E. KIDLER
L.M. FERNANDEZ

REV. DATE 16/3/05
RUN DATE 160305.11

DATA INPUT

GROSS VEHICLE WEIGHT, tons= 19.5
MAXIMUM VELOCITY, mph= 45
ENGINE GROSS HP= 80
LOSS ENGINE HP= 60
FRONTAL AREA, in= 57
COEFFICIENT OF DRAG= 1
TREAD WIDTH, in= 92.51999
TRACK LENGTH, in= 150
TRACK PITCH, in= 6.03
NUMBER OF SPROCKET TEETH= 11
ROLLING RESISTANCE, lb per ton= 100
GRADE, %=-10
COEFFICIENT OF FRICTION= .7
MAXIMUM ACCELERATION, g= .5
DRIVE EFF. @SR>.2= B2
REGENERATION EFF.= 90

RESULTS

VEHICLE LATERAL SPEED ACCELERATION (mph)	TURN RADIUS (ft)	INNER SPROCKET HORSEPOWER (hp)	INNER SPROCKET ROT. SPEED (rpm)	TORQUE (lbft)	HORSEPOWER (hp)	OUTER SPROCKET ROT. SPEED (rpm)	TORQUE (lbft)
45.00	271.35	-302.50	699.67	-2270.73	116.14	735.17	831.99
40.00	214.40	-351.38	617.97	-2906.39	186.40	655.66	1493.14
35.00	164.15	-394.47	535.68	-3867.59	286.34	578.75	2326.25
30.00	120.60	-421.51	452.48	-4892.54	316.79	502.74	3309.52
25.00	83.75	-420.95	367.86	-6010.21	358.04	428.16	4391.93
20.00	95.49	-319.51	297.25	-5645.37	258.50	339.56	3998.23
15.00	182.60	-157.31	230.51	-3584.35	90.09	247.10	1914.77
10.00	175.01	-108.97	153.43	-3730.19	64.22	164.98	2044.57
9.00	165.11	-102.88	137.78	-3921.77	63.28	148.79	2233.72
8.00	155.01	-96.05	122.15	-4129.99	61.59	132.58	2439.76
7.00	146.57	-87.59	106.62	-4314.79	58.06	116.27	2622.63
6.00	139.66	-77.67	91.18	-4473.73	52.86	99.86	2779.91
5.00	134.50	-66.39	75.85	-4597.03	46.06	83.36	2901.80
4.00	132.11	-53.74	60.62	-4655.81	37.61	66.74	2959.42
3.00	136.40	-39.47	45.54	-4552.39	27.17	49.90	2855.10
2.00	173.44	-21.99	30.68	-5765.81	13.00	33.01	2067.88

SEPROCK HORSE POWER

NR12134: E(100)

BY: W. E. RÖDLER

L. V. RICHMANDEZ

REV. DATE: 6/3/85
RUN DATE: 60385.13

DATA INPUT =

GROSS VEHICLE WEIGHT, tons= 19.5
MAXIMUM VELOCITY , mph= 45
ENGINE GROSS HP= 61
LOSS ENGINE HP= 60
FRONTAL AREA , in= 57
COEFFICIENT OF DRAG= 1

TREAD WIDTH,in= 92.51999
TRACK LENGTH,in= 150
TRACK PITCH,in= 6.03
NUMBER OF SPROCKET TEETH
ROLLING RESISTANCE,lb per

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GRADE,%=-10
COEFFICIENT OF FRICTION=.7
MAXIMUM ACCELERATION ,95=.5
DRIVE EFF. GSR>.2=.82
REGENERATION EFF.=.90
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ESL TNGS

VEHICLE SPEED (mph)	LATERAL ACCELERATION (gs)	TURN RADIUS (ft)	INNER SPROCKET			OUTER SPROCKET		
			HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)	HORSEPOWER (hp)	ROT. SPEED (rpm)	TORQUE (lbft)
45.00	0.50	271.35	-302.50	699.67	-2270.73	116.14	733.17	831.99
40.00	0.50	214.40	-351.38	617.97	-2986.39	186.40	655.66	1493.14
35.00	0.50	164.15	-394.46	535.68	-3867.58	256.34	578.75	2326.25
30.00	0.50	120.60	-421.51	452.48	-4892.54	316.79	502.74	3309.52
20	0.50	83.75	-420.95	367.86	-6010.21	358.04	428.16	4391.93
15.00	0.01	2048.82	-49.78	317.42	-823.59	-50.08	319.39	-823.55
10.00	0.00	4746.54	-37.91	238.49	-834.79	-38.01	239.13	-834.79
9.00	0.00	6962.97	-25.52	159.06	-842.81	-25.57	159.35	-842.81
8.00	0.00	7847.88	-23.01	143.17	-844.03	-23.04	143.40	-844.03
7.00	0.00	9943.98	-20.48	127.28	-845.12	-20.51	127.44	-845.12
6.00	0.00	19534.49	-17.95	111.41	-846.08	-17.96	111.48	-846.08

B.6 A-C Induction Motor Drive System Electrical States

A detailed analysis of the operating states of all components was made to assure that all components were operating within normal rated limits. The results are given in the following tables:

1. 19.5 Ton, Configuration I
2. 19.5 Ton, Configuration II
3. 40.0 Ton, Configuration I
4. 40.0 Ton, Configuration II

The voltage, current and frequencies values have been given vs. vehicle speed to illustrate the operational characteristics. These tables confirmed that there were no peculiar operating points to cause failure of the components.

INDUCTION MOTOR CONFIGURATION 1, GVW= 19.5, ELECTRICAL STATE DATA

(DURING MAXIMUM TRACTIVE EFFORT CONDITION)

SPEED MPH	ALTERNATOR					BRIDGES (EACH)		MOTORS(EACH)		
	EXCITER		OUTPUT			INPUT		INPUT		
	"E"	"I"	"E"	"I"	"F"	"E"	"I"	"E"	"I"	"F"
1.5			515	410	250	510	205	82	1253	17
3.0			524	350		262		120	1092	33
4.5			524	500		262		142	924	50
6.0			526			263		161	817	67
7.5			528			264		179	738	83
9.0			530			265		195	681	100
10.5			536			268		210	639	117
12.0								224	600	133
13.5								237	566	150
15.0								249	539	166
16.5								261	515	183
18.0								271	495	200
19.5								282	476	216
21.0								293	458	233
22.5								303	442	250
24.0								314	426	266
25.5								323	415	283
27.0								332	404	300
28.5								341	393	317
30.0								350	383	333
31.5								358	373	350
33.0								367	365	367
34.5								376	357	384
36.0								384	349	400
37.5								392	342	417
39.0								400	335	433
40.5								408	329	450
42.0								417	322	466
43.5								424	316	483
45.0			515	536	500	510	268	432	310	500

INDUCTION MOTOR CONFIGURATION 1, GVW= 40T, ELECTRICAL STATE DATA

(DURING MAXIMUM TRACTIVE EFFORT CONDITION)

SPEED MPH	ALTERNATOR					BRIDGES (EACH)		MOTORS(EACH)		
	EXCITER		OUTPUT			INPUT		INPUT		
	"E"	"I"	"E"	"I"	"F"	"E"	"I"	"E"	"I"	"F"
1.5			412	1148	250	408	574	149	1471	13
3.0				1372	350		686	217	1266	27
4.5				1364	500		682	255	1071	40
6.0				1400			700	296	946	53
7.5				1398			699	327	856	67
9.0				1414			704	357	789	86
10.5			412	1420		408	710	385	738	93
12.0			616	942		612	471	409	692	106
13.5								433	654	120
15.0								455	622	133
16.5								476	595	146
18.0								496	571	160
19.5								516	549	173
21.0								535	529	186
22.5			616	942		612	471	556	510	200
24.0			718	808		714	404	573	494	213
25.5								590	480	227
27.0								608	466	240
28.5								625	453	253
30.0								642	441	267
31.5			718	808		714	404	657	431	270
33.0			820	708		816	354	673	421	293
34.5								689	411	306
36.0								703	403	320
37.5								719	394	333
39.0								734	386	346
40.5								747	379	360
42.0								762	372	373
43.5								776	365	386
45.0			820	708	500	816	354	791	358	400

INDUCTION MOTOR CONFIGURATION II, GVW=19.5, ELECTRICAL STATE DATA

(DURING MAXIMUM TRACTIVE EFFORT CONDITION)

SPEED MPH	ALTERNATOR					BRIDGE (EACH)		MOTOR (EACH)		
	EXCITER		OUTPUT			INPUT		INPUT		
	"E"	"I"	"E"	"I"	"F"	"E"	"I"	"E"	"I"	"F"
1.5			169	1253	250	166	1253	162	1253	17
3.0			249		350	246		240	1092	33
4.5			291		500	288		284	924	50
6.0			329			326		322	817	67
7.5			365			362		358	738	83
9.0			397			394		390	681	100
10.5			427			424		420	639	117
12.0			455			452		448	600	133
13.5			481			478		474	566	150
15.0			505			502		498	539	166
16.5			529			526		522	515	183
18.0			268			265		261	1030	200
19.5			290			287		283	950	216
21.0			311			308		304	882	233
22.5			333			330		326	824	250
24.0			355			352		348	772	266
25.5			376			373		369	727	283
27.0			398			395		391	686	300
28.5			420			417		413	650	317
30.0			442			439		435	618	333
31.5			463			460		456	588	350
33.0			485			482		478	561	367
34.5			507			504		500	537	384
36.0			529			526		522	515	400
37.5			550			547		543	494	417
39.0			572			569		565	475	433
40.5			594			591		587	457	450
42.0			616			613		609	441	466
43.5			637			634		630	426	483
45.0			659	412	500	656	412	652	412	500

INDUCTION MOTOR CONFIGURATION II, GVW= 40T, ELECTRICAL STATE DATA

(DURING MAXIMUM TRACTIVE EFFORT CONDITION)

SPEED MPH	ALTERNATOR					BRIDGES		MOTORS		
	EXCITER		OUTPUT			INPUT		INPUT		
	"E"	"I"	"E"	"I"	"F"	"E"	"I"	"E"	"I"	"F"
1.5			305	147	250	302	147	298	147	13
3.0			441		350	438		434	1266	27
4.5			517		500	514		510	1071	40
6.0			599			596		592	946	53
7.5			661			658		654	856	67
9.0			721			718		714	789	80
10.5			777			774		770	738	93
12.0			416			413		409	1384	106
13.5			410			407		433	1308	120
15.0			462			459		455	1244	133
16.5			483			480		476	1190	146
18.0			503			500		496	1142	160
19.5			523			520		516	1098	173
21.0			542			539		535	1058	186
22.5			563			560		556	1020	200
24.0			600			577		573	988	213
25.5			597			594		590	960	227
27.0			615			612		608	932	240
28.5			632			629		625	906	253
30.0			649			646		642	882	267
31.5			664			661		657	862	270
33.0			670			667		673	842	293
34.5			696			693		689	822	306
36.0			710			707		703	806	320
37.5			726			723		719	788	333
39.0			740			737		734	772	346
40.5			754			751		747	758	360
42.0			769			766		762	744	373
43.5			783			780		776	730	386
45.0			798	358	500	795	358	791	358	400

B.7 Homopolar Motor Drive System Electrical States

A detailed analysis of the operating states of all components was made to assure that they were operating within normal rated limits. The results are given in the following tables:

1. 19.5 Ton, Configuration I
2. 40.0 Ton, Configuration I

The voltage and current values have been given tabulated vs. vehicle speed to illustrate the operational characteristics. These tables confirmed that there were no peculiar operating points to cause failure of the components.

ELECTRIC VEHICLE MISSION SIMULATION

DC HOMOPOLAR Motor Drive System
19.5 Ton

FMC / NORTHERN ORDNANCE DIVISION
MINNEAPOLIS, MINNESOTA USA

REVISION DATE: 06/05/85
RUN DATE: 08-22-1985

ELECTRICALLY DRIVEN, TRACKED VEHICLE PERFORMANCE IS SIMULATED BY THIS PROGRAM. DETAILED ASPECTS OF VEHICLE PERFORMANCE CAN BE INVESTIGATED USING THE FOUR RESIDENT SUB-PROGRAMS LISTED BELOW. THE SUB-PROGRAM IN USE IS IDENTIFIED WITH AN ASTERISK.

- * 1.) ELECTRIC DRIVE PERFORMANCE -
- 2.) VEHICLE ACCELERATION PERFORMANCE -
- 3.) ACCELERATION DYNAMICS ROUTINE -
- 4.) REDUCTION DYNAMICS ROUTINE -

STEADY STATE VEHICLE PERFORMANCE ANALYSIS WITH DETAILED EMPHASIS ON ELECTRIC POWER DRIVE PARAMETERS. ENERGY USAGE, HEAT REJECTION, AND FUEL IMPACT ARE ALSO CALCULATED.

DYNAMIC VEHICLE PERFORMANCE ANALYSIS WHICH REALISTICALLY SIMULATES GROSS VEHICLE MISSION OVER ALL TERRAIN CONDITIONS. ACCELERATION, DECELERATION, BRAKING AND CONSTANT VELOCITY CONDITIONS ARE CONSIDERED.

DETAILED ANALYSIS OF FULL POWER VEHICLE ACCELERATION DURING TURNING AND NON-TURNING MANEUVERS ON USER SELECTED GRADES AND SURFACES. INCREMENTAL DYNAMIC PARAMETERS ARE GENERATED AND TABULATED.

DETAILED ANALYSIS OF SPEED/TORQUE LOADING OF ALL VEHICLE POWER TRAIN REDUCTION ELEMENTS. FINAL SPROCKET DRIVES AND DIESEL ENGINE INTERFACE ARE INCLUDED IN ANALYSIS.

COURSE DATA	VEHICLE DATA	ENGINE DATA	ELECTRIC DRIVE DATA
COURSE: DATA INPUT BY USER	GROSS VEHICLE WEIGHT, tons= 19.5	ENGINE: VTA-903	TYPE: HoPol P-B
SURFACE: COMPACTED SOIL	FRONTAL AREA, sq. ft.= 57	MAX. POWER, hp= 500	PEAK MOTOR EFF., %= 90
COEFFICIENT OF FRICTION=.7	COEFFICIENT OF DRAG= 1	MAX. SPEED, rpm= 2960	GENERATOR EFF., %= .92
PERFORMANCE LIMITS	TREAD WIDTH, in.= 92.5	SPEED FOR MIN. FUEL, rpm= 2100	MOTOR KM V/Krpm-A= .005
	TRACK LENGTH, in.= 150	COOLING LOSSES, % Ghp= 4	GEN. KB, V/Krpm-A= .005
MAX. COURSE VELOCITY, mph= 45	TRACK PITCH, in.= 6.03	INLET/EXHAUST LOSSES, % Ghp= 1.5	
MAX. LAT. ACCEL., g's= .5	NUMBER OF SPROCKET TEETH= 11	AUXILIARY POWER hp= 6	
	ROLLING RESISTANCE, lb. per ton= 100	FUEL CAPACITY, gal.= 175	
	MAXIMUM VELOCITY, mph= 45	SCHEDULING: CONSTANT	

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. LAT.	ENGINE	ELECTRIC
DATA INPUT BY USER	VELOCITY (mph)	SCHEDULING	DRIVE TYPE
	45.00	CONSTANT	HoPol P-G
SURFACE	ACCEL. (g's)		
COMPACTED SOIL	0.50		
		VTA-903	
		19.5 TON	

MISSION COURSE DATA

LAP NO. (#)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	60	0	272.73	1000	272.73	2.50	17.31

VEHICLE PERFORMANCE DATA

FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	INNER SPROCKET HORSEPOWER (hp)	INNER SPROCKET SPEED (rpm)	INNER SPROCKET TORQUE (ft-lb)	INNER SPROCKET HORSEPOWER (hp)	INNER SPROCKET SPEED (rpm)	INNER SPROCKET TORQUE (ft-lb)	NET DRIVE EFFICIENCY (%)
2.50	22.02	0.000	73.40	39.80	9686.34	73.40	39.80	9686.34	29.46

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL CONSUMED (gal.)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
498.30	96056.88	96056.88	67756.57	2600.00	199.18	1.915	173.09	0.10

ELECTRIC DRIVE DATA

GENERATOR				INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
SPEED (rpm)	POWER (Kw)	CURRENT (amps)	VOLTAGE (volts)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)
10400.00	269.21	270557.00	1.00	663.35	599.16	75.67	15.0	663.35	599.16	75.67	15.0

***** *** ELECTRIC DRIVE PERFORMANCE *** *****

***** MISSION PARAMETERS *****

COURSE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	45.00	0.50	19.5 TON	VTA-903	CONSTANT	HoPol P-6
SURFACE	COMPACTED SOIL					

***** MISSION COURSE DATA *****

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	2	1000	57.5	0	227.27	2000	500.00	2.73	20.69

***** VEHICLE PERFORMANCE DATA *****

INNER SPROCKET			OUTER SPROCKET			NET DRIVE EFFICIENCY (%)
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	
3.00	21.39	0.000	85.59	47.76	9411.56	34.24

***** ENGINE / ENERGY DATA *****

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
499.93	80310.51	176367.40	52813.05	2600.00	199.97	171.48	0.12

***** ELECTRIC DRIVE DATA *****

INNER SPROCKET MOTOR			OUTER SPROCKET MOTOR		
GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	BUSS VOLTAGE (volts)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)
10400.00	270.24	1.19	796.02	582.16	88.23
CURRENT (amps)			CURRENT (amps)		
226326.80			113163.40		
FIELD POWER (Kw)			FIELD POWER (Kw)		
15.0			15.0		

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

ELECTRIC
DRIVE TYPE
HoPol P-G

ENGINE
SCHEDULING
CONSTANT

ENGINE
VTA-903

VEHICLE
19.5 TON

MAX. LAT.
ACCEL.
(g's)
0.50

MAX.
VELOCITY
(mph)
45.00

SURFACE
COMPACTED SOIL

COURSE
DATA INPUT BY USER

MISSION COURSE DATA

RANGE
ESTIMATE
(miles)
31.05

AVG. FORWARD
VELOCITY
(mph)
3.14

CUMULATIVE
TIME
(sec)
651.52

CUMULATIVE
DISTANCE
(ft)
3000

TIME
(sec)
151.52

RADIUS
(ft)
0

GRADE
(%)
49.5

DISTANCE
(ft)
1000

SEGMENT NO.
(#)
3

LAP NO.
(#)
1

VEHICLE PERFORMANCE DATA

INNER SPROCKET

OUTER SPROCKET

LATERAL
ACCELERATION
(g's)
0.000

TRACTIVE
EFFORT
(K-lbs)
19.25

FORWARD
VELOCITY
(mph)
4.50

HORSEPOWER
(hp)
115.55

SPEED
(rpm)
71.64

TORQUE
(ft-lb)
8471.20

HORSEPOWER
(hp)
115.55

SPEED
(rpm)
71.64

TORQUE
(ft-lb)
8471.20

NET DRIVE
EFFICIENCY
(%)
46.25

ENGINE / ENERGY DATA

CUMULATIVE
ENERGY USED
(btu)
229881.60

SEGMENT
ENERGY
(btu)
53514.22

HORSEPOWER
GENERATED
(hp)
499.69

SEGMENT
ENERGY LOSS
(btu)
28764.16

ENGINE
SPEED
(rpm)
2600.00

FUEL
CONSUMPTION
(lb/hr)
199.85

FUEL
CONSUMED
(gal.)
1.067

FUEL
REMAINING
(gal.)
170.42

FUEL
ECONOMY
(mpg)
0.18

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR

OUTER SPROCKET MOTOR

GENERATOR
POWER
(Kw)
270.09

GENERATOR
SPEED
(rpm)
10400.00

TORQUE
(ft-lb)
523.99

SPEED
(rpm)
1194.03

TORQUE
(ft-lb)
523.99

HORSEPOWER
(hp)
119.13

BUSS
CURRENT
(amps)
150798.90

BUSS
VOLTAGE
(volts)
1.79

VOLTAGE
(volts)
1.79

CURRENT
(amps)
75399.44

VOLTAGE
(volts)
1.79

CURRENT
(amps)
75399.44

FIELD POWER
(Kw)
15.0

◆◆◆◆◆

MISSION PARAMETERS*****

COURSE	SURFACE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g 's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
19.5	IRON	0.50		VTA-903	CONSTANT	HoPol P-G	

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*****
MISSION COURSE DATA
*****
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LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
		1000	4.2	0	113.44	4000	745.15	3.57	41.58

VEHICLE PERFORMANCE DATA

FORWARD VELOCITY (mph)	TRACTIVE EFFORT (k-lbs)	LATERAL ACCELERATION (g's)		INNER SPROCKET		OUTER SPROCKET		NET DRIVE EFFICIENCY (%)
				HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	SPEED (rpm)	
4.00	17.06	0.000		136.49	95.52	136.49	95.52	54.83

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*****
ENGINE \ ENERGY DATA
*****

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HORSEPOWER GENERATED	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL CONSUMED, (gal.)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
497.89	39991.02	269872.60	18065.08	2600.00	198.99	0.797	169.62	0.24

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*****
ELECTRIC DRIVE DATA
*****
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GENERATOR		INNER SPROCKET MOTOR			OUTER SPROCKET MOTOR		
SPEED (rpm)	POWER (Kw)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)
10400.00	268.96	1592.04	464.20	140.71	1592.04	464.20	140.71
BUSS		FIELD POWER			FIELD POWER		
VOLTAGE (volts)	CURRENT (amps)	VOLTAGE (volts)	CURRENT (amps)	(Kw)	VOLTAGE (volts)	CURRENT (amps)	(Kw)
2.39	112625.00	2.39	56312.49	15.0	2.39	56312.49	15.0

✱
✱
✱
✱

✻
✻
✻
✻

ENGINE
SCHEDULING

CONSTANT

ELECTRIC
DRIVE TYPE

RANGE
ESTIMATE
(miles)
51.98

AVG. FORWARD
VELOCITY
(mph)
3.98

CUMULATIVE
TIME
(sec)
856.06

CUMULATIVE
DISTANCE
(ft)
5000

TIME
(sec)
90.91

ADJUS
(ft)

GRADE (%)

DISTANCE
(ft)
1000

SEGMENT NO.
(#)
5

LAP NO. _____
(#) _____

●●●●

FORWARD VELOCITY (mph)	TRACTION EFFORT (K-lbs)
7.50	14.94

LATERAL
ACCELERATION
(g's)
0.000

SPEED
(rpm)
119.40

TORQUE
(ft-lb)
6573.10

HORSEPOWER
(hp)
149.42

SPEED
(rpm)
119.40

TORQUE
(ft-lb)
6573.10

NET DRIVE
EFFICIENCY
(%)
60.03

崇禎四年

HORSEPOWER GENERATED	SEGMENT ENERGY (btu)
497.86	31991.15

CUMULATIVE
ENERGY USED
(btu)
301863.80

SEGMENT
ENERGY LOSS
(btu)
12786.72

ENGINE
SPEED
(rpm)
2600.00

FUEL
SUMPTION
lb/hr)
98.97

FUEL
CONSUMED
(gal.)
0.638

FUEL
REMAINING
(gal.)
168.98

FUEL
ECONOMY
(mpg)
0.30

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GENERATOR
SPEED
(rpm)
10400.00

GENERATOR
POWER
(KW)
268.94

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-----
RSEPOWER
      (hp)
      154.06

```

SPEED
(rpm)
1990.05

RSEPOWER
(hp)
154.06

```

BUSS
VOLTAGE
(volts)
2.99

```

BUSS
CURRENT
(amps)
90094.49

CURRENT
(amps)
45047.25

LD POWER
(KW)
15.0

VOLTAGE
(volts)
2.99

CURRENT
(amps)
45047.25

LD POWER
(KW)
15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

ELECTRIC
DRIVE TYPE
HoPol P-6

ENGINE
SCHEDULING
CONSTANT

MAX. LAT.
ACCEL.
(g's)
0.50

MAX. VELOCITY
(mph)
45.00

SURFACE
COMPACTED SOIL

COURSE

DATA INPUT BY USER

VEHICLE
19.5 TON

ENGINE
VTA-903

MISSION COURSE DATA

RANGE
ESTIMATE
(miles)
62.72

AVG. FORWARD
VELOCITY
(mph)
4.39

CUMULATIVE
TIME
(sec)
931.82

CUMULATIVE
DISTANCE
(ft)
6000

TIME
(sec)
75.76

RADIUS
(ft)
0

GRADE
(%)
28.8

DISTANCE
(ft)
1000

SEGMENT NO.
(#)
6

LAP NO.
(#)
1

VEHICLE PERFORMANCE DATA

NET DRIVE
EFFICIENCY
(%)
61.79

TORQUE
(ft-lb)
5611.78

SPEED
(rpm)
143.28

HORSEPOWER
(hp)
153.10

TORQUE
(ft-lb)
5611.78

SPEED
(rpm)
143.28

HORSEPOWER
(hp)
153.10

LATERAL
ACCELERATION
(g's)
0.000

TRACTIVE
EFFORT
(K-lbs)
12.76

FORWARD
VELOCITY
(mph)
9.00

SEGMENT
ENERGY
(btu)
26536.36

HORSEPOWER
GENERATED
(hp)
495.57

INNER SPROCKET

OUTER SPROCKET

ENGINE / ENERGY DATA

FUEL
ECONOMY
(mpg)
0.36

FUEL
REMAINING
(gal.)
168.45

FUEL
CONSUMED
(gal.)
0.528

FUEL
CONSUMPTION
(lb/hr)
197.87

ENGINE
SPEED
(rpm)
2600.00

SEGMENT
ENERGY LOSS
(btu)
10140.59

CUMULATIVE
ENERGY USED
(btu)
328400.10

GENERATOR
POWER
(Kw)
267.49

BUSS
CURRENT
(amps)
74675.68

GENERATOR
SPEED
(rpm)
10400.00

BUSS
VOLTAGE
(volts)
3.58

INNER SPROCKET MOTOR

OUTER SPROCKET MOTOR

ELECTRIC DRIVE DATA

TORQUE
(ft-lb)
347.12

SPEED
(rpm)
2388.06

HORSEPOWER
(hp)
157.83

TORQUE
(ft-lb)
347.12

SPEED
(rpm)
2388.06

HORSEPOWER
(hp)
157.83

GENERATOR
POWER
(Kw)
267.49

BUSS
CURRENT
(amps)
74675.68

GENERATOR
SPEED
(rpm)
10400.00

BUSS
VOLTAGE
(volts)
3.58

INNER SPROCKET MOTOR

OUTER SPROCKET MOTOR

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

ELECTRIC
DRIVE TYPE
HoPol P-G

ENGINE
SCHEDULING
CONSTANT

ENGINE
VTA-903

VEHICLE
19.5 TON

MAX. LAT.
ACCEL.
(g's)
0.50

MAX.
VELOCITY
(mph)
45.00

SURFACE
COMPACTED SOIL

COURSE
DATA INPUT BY USER

MISSION COURSE DATA

RANGE
ESTIMATE
(miles)
72.81

AVG. FORWARD
VELOCITY
(mph)
4.79

CUMULATIVE
TIME
(sec)
996.75

CUMULATIVE
DISTANCE
(ft)
7000

TIME
(sec)
64.94

RADIUS
(ft)
0

GRADE
(%)
24

DISTANCE
(ft)
1000

SEGMENT NO.
(#)
7

LAP NO.
(#)
1

VEHICLE PERFORMANCE DATA

INNER SPROCKET

NET DRIVE
EFFICIENCY
(%)
62.29

TORQUE
(ft-lb)
4869.35

SPEED
(rpm)
167.16

HORSEPOWER
(hp)
154.98

TORQUE
(ft-lb)
4869.35

SPEED
(rpm)
167.16

HORSEPOWER
(hp)
154.98

LATERAL
ACCELERATION
(g's)
0.000

TRACTION
EFFORT
(K-lbs)
11.07

FORWARD
VELOCITY
(mph)
10.50

ENGINE / ENERGY DATA

FUEL
ECONOMY
(mpg)
0.42

FUEL
REMAINING
(gal.)
168.00

FUEL
CONSUMED
(gal.)
0.455

FUEL
CONSUMPTION
(lb/hr)
198.86

ENGINE
SPEED
(rpm)
2600.00

SEGMENT
ENERGY LOSS
(btu)
8613.30

CUMULATIVE
ENERGY USED
(btu)
351240.10

SEGMENT
ENERGY
(btu)
22839.93

HORSEPOWER
GENERATED
(hp)
497.63

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR

GENERATOR
POWER
(Kw)
268.79

GENERATOR
SPEED
(rpm)
10400.00

HORSEPOWER
(hp)
159.78

SPEED
(rpm)
2786.07

HORSEPOWER
(hp)
159.78

TORQUE
(ft-lb)
301.20

SPEED
(rpm)
2786.07

POWER
(Kw)
268.79

BUSS
CURRENT
(amps)
64317.49

BUSS
VOLTAGE
(volts)
4.18

FIELD POWER
(Kw)
15.0

CURRENT
(amps)
32158.75

VOLTAGE
(volts)
4.18

FIELD POWER
(Kw)
15.0

CONSUMPTION
(lb/hr)
198.86

ENERGY LOSS
(btu)
8613.30

ACCELERATION
(g's)
0.000

EFFORT
(K-lbs)
11.07

VELOCITY
(mph)
10.50

TIME
(sec)
64.94

DISTANCE
(ft)
1000

GRADE
(%)
24

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. LAT.	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	VELOCITY (mph)	ENGINE	
	ACCEL. (g's)	VTA-903	HoPol P-G
	45.00	19.5 TON	
	0.50	CONSTANT	
SURFACE			
COMPACTED SOIL			

MISSION COURSE DATA

LAP NO.	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
(#)				
1	1000	1053.57	5.18	83.13
	20.4			
	0			
	56.82			

VEHICLE PERFORMANCE DATA

FORWARD VELOCITY (mph)	INNER SPROCKET	OUTER SPROCKET	NET DRIVE EFFICIENCY (%)
12.00			62.76
	TRACTION EFFORT (K-lbs)		
	9.77		
	LATERAL ACCELERATION (g's)		
	0.000		
	HORSEPOWER (hp)		
	156.30		
	TORQUE (ft-lb)		
	4296.88		
	SPEED (rpm)		
	191.04		
	HORSEPOWER (hp)		
	156.30		
	TORQUE (ft-lb)		
	4296.88		
	SPEED (rpm)		
	191.04		

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	FUEL CONSUMED (gal.)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
498.05	371242.00	7447.89	0.399	167.60	0.48
	20001.95				

ELECTRIC DRIVE DATA

GENERATOR SPEED (rpm)	INNER SPROCKET MOTOR	OUTER SPROCKET MOTOR	FIELD POWER (Kw)
10400.00			15.0
	GENERATOR POWER (Kw)		
	269.06		
	BUSS CURRENT (amps)		
	56333.56		
	VOLTAGE (volts)		
	4.78		
	CURRENT (amps)		
	28166.78		
	VOLTAGE (volts)		
	4.78		
	FIELD POWER (Kw)		
	15.0		
	CURRENT (amps)		
	28166.78		
	TORQUE (ft-lb)		
	265.79		
	HORSEPOWER (hp)		
	161.13		
	SPEED (rpm)		
	3184.08		
	TORQUE (ft-lb)		
	265.79		
	HORSEPOWER (hp)		
	161.13		

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE DATA INPUT BY USER

MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
45.00	0.50	19.5 TON	VTA-903	CONSTANT	HoPol P-G

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	9	1000	17.6	0	50.51	9000	1104.08	5.56	93.62

VEHICLE PERFORMANCE DATA

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (k-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	63.22
13.50	8.74	0.000	157.30	214.93	3843.81	157.30	214.93	

ENGINE / ENERGY DATA

FUEL CONSUMPTION				FUEL REMAINING				FUEL ECONOMY (mpg)
HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMED (gal.)	FUEL REMAINING (gal.)	HORSEPOWER (hp)		0.53
497.60	17763.41	6533.06	2600.00	0.354	167.24	162.16		

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)
10400.00	268.77	5.37	25010.76	3582.09	237.76	162.16	15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE DATA INPUT BY USER

LAP NO. (#)	SEGMENT NO. (#)	SURFACE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	11	1000	13.7	0	41.32	11000	1190.85	6.30	113.95

VEHICLE PERFORMANCE DATA

FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	INNER SPROCKET			OUTER SPROCKET			NET DRIVE EFFICIENCY (%)
			HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	
16.50	7.28	0.000	160.27	262.69	3204.36	160.27	262.69	3204.36	64.19

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
499.34	14584.39	419573.00	5222.31	2600.00	199.68	166.64	0.65

ELECTRIC DRIVE DATA

GENERATOR				INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR				BUSS			
SPEED (rpm)	10400.00	POWER (Kw)	269.86	SPEED (rpm)	4378.11	TORQUE (ft-lb)	198.21	SPEED (rpm)	4378.11	TORQUE (ft-lb)	198.21	VOLTAGE (volts)	6.57	CURRENT (amps)	20546.45
VOLTAGE (volts)	6.57	CURRENT (amps)	41092.89	TORQUE (ft-lb)	198.21	HORSEPOWER (hp)	165.22	HORSEPOWER (hp)	165.22	VOLTAGE (volts)	6.57	FIELD POWER (Kw)	15.0	CURRENT (amps)	20546.45

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MISSION PARAMETERS

COURSE	SURFACE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	COMPACTED SOIL	45.00	0.50	19.5 TON	VTA-903	CONSTANT	Hydrol P-G

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	12	1000	12.2	0	37.88	12000	1228.73	6.66	124.40

VEHICLE PERFORMANCE DATA

FORWARD VELOCITY (mph)	TRACTION EFFORT (K-lbs)	LATERAL ACCELERATION			HORSEPOWER			TORQUE			NET DRIVE EFFICIENCY (%)
		(g's)	(hp)	(rpm)	(ft-lb)	(hp)	(rpm)	(ft-lb)			
18.00	6.72	0.000	161.32	286.57	161.32	286.57	2956.65	2956.65	64.65		

ENGINE / ENERGY DATA

HORSEPOWER GENERATED	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL CONSUMED (gal.)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
400.04 (hp)	13361.01 (btu)	432934.00 (btu)	4722.66 (btu)	2600.00 (rpm)	199.54 (lb/hr)	0.266 (gal.)	166.37 (gal.)	0.71 (mpg)

ELECTRIC DRIVE DATA

GENERATOR SPEED (rpm)	10400.00	GENERATOR POWER (Kw)	259.68	INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
				SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)		SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	
				4776.12	182.89	166.31		4776.12	182.89	166.31	
BUSS VOLTAGE (volts)	7.16	BUSS CURRENT (amps)	37642.21					VOLTAGE (volts)	CURRENT (amps)	FIELD POWER (Kw)	
	7.16							7.16	18821.11	15.0	

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	45.00	0.50	19.5 TON	VTA-903	CONSTANT	HoPol P-G
	SURFACE					
	COMPACTED SOIL					

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	14	1000	9.640001	0	32.47	14000	1296.16	7.37	145.26

VEHICLE PERFORMANCE DATA

INNER SPROCKET				OUTER SPROCKET		NET DRIVE EFFICIENCY (%)
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	
21.00	5.76	0.000	161.22	334.33	2532.67	64.66

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ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
498.65	11443.52	456690.60	4043.90	2600.00	199.35	165.90	0.83

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	BUS VOLTAGE (volts)	BUS CURRENT (amps)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)
10400.00	269.44	8.36	32235.98	5572.14	156.66	166.21	15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE DATA INPUT BY USER SURFACE COMPACTED SOIL MAX. VELOCITY (mph) 45.00 MAX. LAT. ACCEL. (g's) 0.50 VEHICLE 19.5 TON ENGINE VTA-903 SCHEDULING CONSTANT ELECTRIC DRIVE TYPE HoPol P-6

MISSION COURSE DATA

LAP NO. 1 SEGMENT NO. 16 DISTANCE (ft) 1000 GRADE (%) 7.74 RADIUS (ft) 0 TIME (sec) 28.41 CUMULATIVE DISTANCE (ft) 16000 CUMULATIVE TIME (sec) 1354.88 AVG. FORWARD VELOCITY (mph) 8.06 RANGE ESTIMATE (miles) 165.79

VEHICLE PERFORMANCE DATA

FORWARD VELOCITY (mph) 24.00 TRACTIVE EFFORT (K-lbs) 5.04 LATERAL ACCELERATION (g's) 0.000 HORSEPOWER (hp) 161.43 SPEED (rpm) 382.09 TORQUE (ft-lb) 2218.99 INNER SPROCKET TORQUE (ft-lb) 161.43 SPEED (rpm) 382.09 FUEL CONSUMPTION (gal.) 0.200 FUEL REMAINING (gal.) 165.48 FUEL ECONOMY (mpg) 0.95 NET DRIVE EFFICIENCY (%) 64.67

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp) 499.21 CUMULATIVE ENERGY USED (btu) 477383.10 SEGMENT ENERGY LOSS (btu) 3541.20 ENGINE SPEED (rpm) 2600.00 FUEL CONSUMPTION (lb/hr) 199.62 FUEL REMAINING (gal.) 165.48 FUEL ECONOMY (mpg) 0.95

ELECTRIC DRIVE DATA

GENERATOR SPEED (rpm) 10400.00 GENERATOR POWER (Kw) 269.79 BUS VOLTAGE (volts) 9.55 BUS CURRENT (amps) 28243.41 INNER SPROCKET MOTOR SPEED (rpm) 6368.16 TORQUE (ft-lb) 137.26 HORSEPOWER (hp) 166.42 OUTER SPROCKET MOTOR SPEED (rpm) 6368.16 TORQUE (ft-lb) 137.26 HORSEPOWER (hp) 166.42 VOLTAGE (volts) 9.55 CURRENT (amps) 14121.70 FIELD POWER (Kw) 15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

MAX. LAT. ACCEL. (g's)		0.50		VEHICLE		19.5 TON		ENGINE		VTA-903		ENGINE SCHEDULING		CONSTANT		ELECTRIC DRIVE TYPE		HoPol P-G	
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MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	17	1000	6.95	0	26.74	17000	1381.61	8.39	176.08

VEHICLE PERFORMANCE DATA

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)							
FORWARD VELOCITY (mph)	25.50	TRACTIVE EFFORT (K-lbs)	4.75	LATERAL ACCELERATION (g's)	0.000	HORSEPOWER (hp)	161.49	TORQUE (ft-lb)	2089.29	SPEED (rpm)	405.97	TORQUE (ft-lb)	2089.29	NET DRIVE EFFICIENCY (%)	64.68

ENGINE / ENERGY DATA

CUMULATIVE ENERGY USED (btu)				SEGMENT ENERGY (btu)				FUEL CONSUMPTION (lb/hr)				FUEL REMAINING (gal.)				FUEL ECONOMY (mpg)	
HORSEPOWER GENERATED (hp)	499.38	SEGMENT ENERGY (btu)	9437.89	CUMULATIVE ENERGY USED (btu)	486821.00	ENERGY LOSS (btu)	3333.69	ENGINE SPEED (rpm)	2600.00	FUEL CONSUMPTION (lb/hr)	199.70	FUEL REMAINING (gal.)	165.29	FUEL ECONOMY (mpg)	1.01		

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR				FIELD POWER									
GENERATOR SPEED (rpm)	10400.00	GENERATOR POWER (Kw)	269.89	SPEED (rpm)	6766.17	TORQUE (ft-lb)	129.23	SPEED (rpm)	6766.17	TORQUE (ft-lb)	129.23	CURRENT (amps)	13296.29	VOLTAGE (volts)	10.15	FIELD POWER (Kw)	15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. VEL.	MAX. LAT.	ENGINE	ELECTRIC
DATA INPUT BY USER	VELOCITY (mph)	ACCEL. (g's)	SCHEDULING	DRIVE TYPE
COMPACTED SOIL	45.00	0.50	CONSTANT	HoPol P-B

MISSION COURSE DATA

LAP NO. (#)	GRADE (%)	RADIUS (ft)	CUMULATIVE DISTANCE (ft)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	6.25	0	18000	8.73	186.27

VEHICLE PERFORMANCE DATA

INNER SPROCKET			OUTER SPROCKET		
FORWARD VELOCITY (mph)	LATERAL ACCELERATION (g's)	TRACTIVE EFFORT (K-lbs)	HORSEPOWER (hp)	TORQUE (ft-lb)	SPEED (rpm)
27.00	0.000	4.49	161.64	1775.01	429.85
				TORQUE (ft-lb)	NET DRIVE EFFICIENCY (%)
				1775.01	64.69

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
499.77	495741.60	3150.21	2600.00	199.89	165.12	1.06

ELECTRIC DRIVE DATA

GENERATOR			INNER SPROCKET MOTOR			OUTER SPROCKET MOTOR		
SPEED (rpm)	POWER (Kw)	BUSS CURRENT (amps)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)
10400.00	270.14	25138.04	7164.18	122.17	166.64	7164.18	122.17	166.64
			VOLTAGE (volts)	CURRENT (amps)	FIELD POWER (Kw)	VOLTAGE (volts)	CURRENT (amps)	FIELD POWER (Kw)
			10.75	12569.02	15.0	10.75	12569.02	15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	45.00	0.50	19.5 TON	VTA-903	CONSTANT	HoPol P-G

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVS. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	19	1000	5.6	0	23.92	19000	1430.79	9.06	196.79

VEHICLE PERFORMANCE DATA

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)
28.50	4.25	0.000	161.50	453.73	1869.40	161.50	453.73	1869.40
								64.68

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL CONSUMED (gal.)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
499.39	8444.59	504186.20	2982.92	2600.00	199.71	0.168	164.95	1.12

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	CURRENT (amps)
10400.00	269.90	11.34	23793.88	7562.19	115.63	166.49	11896.94
				VOLTAGE (volts)	CURRENT (amps)	FIELD POWER (Kw)	FIELD POWER (Kw)
				11.34	11896.94	15.0	15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

ELECTRIC
DRIVE TYPE
HoPol P-6

ENGINE
SCHEDULING
CONSTANT

ENGINE
VTA-903

MAX. LAT.
ACCEL.
(g's)
0.50

MAX.
VELOCITY
(mph)
45.00

VEHICLE
19.5 TON

COURSE

DATA INPUT BY USER

SURFACE
COMPACTED SOIL

MISSION COURSE DATA

RANGE
ESTIMATE
(miles)
228.00

AVG. FORWARD
VELOCITY
(mph)
10.03

CUMULATIVE
TIME
(sec)
1495.82

CUMULATIVE
DISTANCE
(ft)
22000

TIME
(sec)
20.66

RADIUS
(ft)
0

GRADE
(%)
4

DISTANCE
(ft)
1000

SEGMENT NO.
(#)
22

LAP NO.
(#)
1

VEHICLE PERFORMANCE DATA

NET DRIVE
EFFICIENCY
(%)
64.67

TORQUE
(ft-lb)
1613.57

SPEED
(rpm)
525.37

HORSEPOWER
(hp)
161.41

TORQUE
(ft-lb)
1613.57

SPEED
(rpm)
525.37

HORSEPOWER
(hp)
161.41

LATERAL
ACCELERATION
(g's)
0.000

GRADE
(%)
4

DISTANCE
(ft)
1000

SEGMENT NO.
(#)
22

LAP NO.
(#)
1

ENGINE / ENERGY DATA

FUEL
ECONOMY
(mpg)
1.30

FUEL
REMAINING
(gal.)
164.49

FUEL
CONSUMED
(gal.)
0.145

FUEL
CONSUMPTION
(lb/hr)
199.59

ENGINE
SPEED
(rpm)
2600.00

SEGMENT
ENERGY LOSS
(btu)
2575.19

CUMULATIVE
ENERGY USED
(btu)
527131.10

SEGMENT
ENERGY
(btu)
7289.51

HORSEPOWER
GENERATED
(hp)
499.15

FORWARD
VELOCITY
(mph)
33.00

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR

GENERATOR
POWER
(Kw)
269.75

GENERATOR
SPEED
(rpm)
10400.00

BUSS
VOLTAGE
(volts)
13.13

BUSS
CURRENT
(amps)
20537.63

VOLTAGE
(volts)
13.13

CURRENT
(amps)
10268.82

FIELD POWER
(Kw)
15.0

TORQUE
(ft-lb)
99.81

SPEED
(rpm)
8756.23

HORSEPOWER
(hp)
166.40

OUTER SPROCKET MOTOR

TORQUE
(ft-lb)
99.81

SPEED
(rpm)
8756.23

HORSEPOWER
(hp)
166.40

VOLTAGE
(volts)
13.13

CURRENT
(amps)
10268.82

FIELD POWER
(Kw)
15.0

TORQUE
(ft-lb)
99.81

SPEED
(rpm)
8756.23

HORSEPOWER
(hp)
166.40

VOLTAGE
(volts)
13.13

CURRENT
(amps)
10268.82

FIELD POWER
(Kw)
15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE		MAX. LAT. ACCEL.		ENGINE SCHEDULING		ELECTRIC DRIVE TYPE	
SURFACE		MAX. VELOCITY (mph)		VEHICLE		CONSTANT	
COMPACTED SOIL		45.00		19.5 TON		HoPol P-6	

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	23	1000	3.56	0	19.76	23000	1515.59	10.35	238.15

VEHICLE PERFORMANCE DATA

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)	
FORWARD VELOCITY (mph)	TRACTION EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	TORQUE (ft-lb)	SPEED (rpm)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	64.68
34.50	3.51	0.000	161.54	1544.73	549.25	161.54	549.25	1544.73	

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)		CUMULATIVE ENERGY USED (btu)		SEGMENT ENERGY LOSS (btu)		ENGINE SPEED (rpm)		FUEL CONSUMED (gal.)		FUEL REMAINING (gal.)		FUEL ECONOMY (mpg)	
499.52		534108.80		2464.48		2600.00		0.139		164.35		1.36	
6977.67													

ELECTRIC DRIVE DATA

GENERATOR				INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR				FIELD POWER			
SPEED (rpm)		POWER (Kw)		TORQUE (ft-lb)		HORSEPOWER (hp)		SPEED (rpm)		TORQUE (ft-lb)		HORSEPOWER (hp)		CURRENT (amps)	
10400.00		269.98		9154.25		95.55		9154.25		95.55		166.54		9830.71	
13.73		19661.41		13.73		15.0		13.73		15.0		15.0		15.0	

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

ELECTRIC
DRIVE TYPE
HoPol P-G

ENGINE
SCHEDULING
CONSTANT

ENGINE
VTA-903

VEHICLE
19.5 TON

MAX. LAT.
ACCEL.
(g's)
0.50

MAX.
VELOCITY
(mph)
45.00

SURFACE
COMPACTED SOIL

COURSE
DATA INPUT BY USER

MISSION COURSE DATA

RANGE
ESTIMATE
(miles)
269.08

AVG. FORWARD
VELOCITY
(mph)
11.30

CUMULATIVE
TIME
(sec)
1570.19

CUMULATIVE
DISTANCE
(ft)
26000

TIME
(sec)
17.48

RADIUS
(ft)
0

GRADE
(%)
2.4

DISTANCE
(ft)
1000

SEGMENT NO.
(#)
26

LAP NO.
(#)
1

VEHICLE PERFORMANCE DATA

NET DRIVE
EFFICIENCY
(%)
64.68

TORQUE
(ft-lb)
1367.17

SPEED
(rpm)
620.90

HORSEPOWER
(hp)
161.63

TORQUE
(ft-lb)
1367.17

SPEED
(rpm)
620.90

HORSEPOWER
(hp)
161.63

LATERAL
ACCELERATION
(g's)
0.000

TRACTIVE
EFFORT
(K-lbs)
3.11

FORWARD
VELOCITY
(mph)
39.00

B-161

ENGINE / ENERGY DATA

HORSEPOWER
GENERATED
(hp)
499.73

SEGMENT
ENERGY
(btu)
6175.19

CUMULATIVE
ENERGY USED
(btu)
553388.80

SEGMENT
ENERGY LOSS
(btu)
2180.78

ENGINE
SPEED
(rpm)
2600.00

FUEL
CONSUMPTION
(lb/hr)
199.87

FUEL
CONSUMED
(gal.)
0.123

FUEL
REMAINING
(gal.)
163.97

FUEL
ECONOMY
(mpg)
1.54

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR

GENERATOR
SPEED
(rpm)
10400.00

GENERATOR
POWER
(Kw)
270.11

SPEED
(rpm)
10348.27

TORQUE
(ft-lb)
84.57

HORSEPOWER
(hp)
166.62

TORQUE
(ft-lb)
84.57

HORSEPOWER
(hp)
166.62

BUSS
VOLTAGE
(volts)
15.52

BUSS
CURRENT
(amps)
17401.44

VOLTAGE
(volts)
15.52

CURRENT
(amps)
8700.72

FIELD POWER
(Kw)
15.0

VOLTAGE
(volts)
15.52

CURRENT
(amps)
8700.72

FIELD POWER
(Kw)
15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. LAT.	ENGINE	ELECTRIC
DATA INPUT BY USER	VELOCITY (mph)	SCHEDULING	DRIVE TYPE
SURFACE	ACCEL. (g's)	CONSTANT	HoPol P-G
COMPACTED SOIL	0.50		
	45.00	VTA-903	
	19.5 TON		

MISSION COURSE DATA

LAP NO. (#)	GRADE (%)	RADIUS (ft)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	2.05	0	27000	1587.03	11.61	279.81
27						

VEHICLE PERFORMANCE DATA

FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	INNER SPROCKET HORSEPOWER (hp)	INNER SPROCKET SPEED (rpm)	INNER SPROCKET TORQUE (ft-lb)	INNER SPROCKET HORSEPOWER (hp)	INNER SPROCKET SPEED (rpm)	INNER SPROCKET TORQUE (ft-lb)	OUTER SPROCKET SPEED (rpm)	OUTER SPROCKET TORQUE (ft-lb)	NET DRIVE EFFICIENCY (%)
40.50	2.99	0.000	161.41	644.78	1314.81	161.41	644.78	1314.81	644.78	1314.81	64.67

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
499.17	5939.78	559338.50	2098.35	2600.00	199.60	0.118	1.60

ELECTRIC DRIVE DATA

GENERATOR SPEED (rpm)	GENERATOR POWER (kw)	BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	INNER SPROCKET MOTOR SPEED (rpm)	INNER SPROCKET MOTOR TORQUE (ft-lb)	INNER SPROCKET MOTOR HORSEPOWER (hp)	OUTER SPROCKET MOTOR SPEED (rpm)	OUTER SPROCKET MOTOR TORQUE (ft-lb)	OUTER SPROCKET MOTOR HORSEPOWER (hp)	VOLTAGE (volts)	CURRENT (amps)	FIELD POWER (Kw)
10400.00	269.76	16.12	16734.97	10746.28	81.33	166.41	10746.28	81.33	166.41	16.12	8367.49	15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	ENGINE	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	45.00	0.50	VTA-903	HoPol P-G
SURFACE	19.5 TON		CONSTANT	
COMPACTED SOIL				

MISSION COURSE DATA

LAP NO. (#)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	1.74	0	16.23	28000	1603.26	11.91	289.76
28							

VEHICLE PERFORMANCE DATA

FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	INNER SPROCKET HORSEPOWER (hp)	INNER SPROCKET SPEED (rpm)	INNER SPROCKET TORQUE (ft-lb)	INNER SPROCKET HORSEPOWER (hp)	INNER SPROCKET SPEED (rpm)	INNER SPROCKET TORQUE (ft-lb)	NET DRIVE EFFICIENCY (%)
42.00	2.89	0.000	161.63	668.66	1269.58	161.63	668.66	1269.58	64.69

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
499.75	5734.37	2025.07	2600.00	199.88	163.73	1.66

ELECTRIC DRIVE DATA

GENERATOR			INNER SPROCKET MOTOR			OUTER SPROCKET MOTOR		
SPEED (rpm)	POWER (Kw)	VOLTAGE (volts)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)
10400.00	270.13	16.72	11144.29	78.53	166.63	11144.29	78.53	166.63
BUS VOLTAGE (volts)	BUS CURRENT (amps)	FIELD POWER (Kw)	VOLTAGE (volts)	CURRENT (amps)	FIELD POWER (Kw)	VOLTAGE (volts)	CURRENT (amps)	FIELD POWER (Kw)
16.72	16159.34	15.0	16.72	8079.67	15.0	16.72	8079.67	15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE
DATA INPUT BY USER

MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
45.00	0.50	19.5 TON	VTA-903	CONSTANT	HoPd1 P-G

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft.)	GRADE (%)	RADIUS (ft.)	TIME (sec)	CUMULATIVE DISTANCE (ft.)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	29	1000	1.44	0	15.67	29000	1618.93	12.22	299.97

VEHICLE PERFORMANCE DATA

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)
43.50	2.79	0.000	161.71	692.54	1226.35	161.71	692.54	1226.35

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL CONSUMED (gal.)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
499.94	5538.76	570601.60	1985.77	2600.00	199.97	0.110	163.62	1.71

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	CURRENT (amps)
10400.00	270.25	17.31	15609.09	11542.30	75.86	166.71	7804.55
				VOLTAGE (volts)	CURRENT (amps)	FIELD POWER (Kw)	FIELD POWER (Kw)
				17.31	7804.55	15.0	15.0

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SURFACE

COMPACTED SOIL

DATA INPUT BY USER

◆◆◆◆◆

DISTANCE
(ft)

LAP NO.	SEGMENT NO.
(#)	(#)
1	30

100

LATERAL
ACCELERATION
(g's)

FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)
45.00	2.64

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CUMMULATIVE
ENERGY USED
(btu)

HORSEPOWER GENERATED	SEGMENT ENERGY
(hp)	(btu)
490.49	5252.86

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GENERATOR
POWER
(KW)

FIELD POWER
(Kw)
15.0

VOLTAGE	CURRENT
(volts)	(amps)
17.91	7378.37

FIELD POWER
(Kw)
15.0

CURRENT
(amps)
7378.37

VOLTAGE
(volts)
17.91

BUSS
CURRENT
(amps)
14756.74

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. VEL.	MAX. LAT.	ENGINE	ELECTRIC
DATA INPUT BY USER	VELOCITY (mph)	ACCEL. (g's)	SCHEDULING	DRIVE TYPE
COMPACTED SOIL	45.00	0.50	CONSTANT	HoPol P-G

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	1	1000	60	0	145.07	1000	145.07	4.70	32.45

VEHICLE PERFORMANCE DATA

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	56.69
4.70	45.16	0.000	283.09	59.17	25126.20	283.09	59.17	

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
998.78	102412.50	44358.01	3200.00	399.41	347.96	0.09
	102412.50					

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)
10400.00	579.95	1036.13	291.84	1479.34	1036.13	291.84	15.0
BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	VOLTAGE (volts)	CURRENT (amps)	VOLTAGE (volts)	CURRENT (amps)	FIELD POWER (Kw)	
2.22	261356.30	2.22	130678.10	2.22	130678.10	15.0	

***** ELECTRIC DRIVE PERFORMANCE *****

***** MISSION PARAMETERS *****

COURSE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	ENGINE	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	45.00	0.50	AD-1000	HoPol P-6
SURFACE			SCHEDULING	
COMPACTED SOIL			CONSTANT	

***** MISSION COURSE DATA *****

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	2	1000	49.4	0	113.64	2000	258.70	5.27	41.62

***** VEHICLE PERFORMANCE DATA *****

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)
6.00	39.44	0.000	315.58	75.54	21941.26	315.58	75.54	21941.26
								63.43

***** ENGINE / ENERGY DATA *****

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
995.06	79924.40	182336.90	29238.82	3200.00	397.63	1.593	0.12

***** ELECTRIC DRIVE DATA *****

GENERATOR				INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
SPEED (rpm)	POWER (Kw)	CURRENT (amps)	VOLTAGE (volts)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)
10400.00	577.62	203903.50	2.83	1888.52	904.79	325.34	15.0	1888.52	904.79	325.34	15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. VEL.	MAX. LAT. ACCEL.	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	(mph)	(g's)	40 TON	AD-1000	CONSTANT	HoPol P-G
	45.00	0.50				

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	3	1000	38.8	0	90.91	3000	349.61	5.85	52.19

VEHICLE PERFORMANCE DATA

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)	
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	TORQUE (ft-lb)	SPEED (rpm)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	(%)
7.50	32.95	0.000	329.55	18330.20	94.43	329.55	94.43	18330.20	66.41

ENGINE / ENERGY DATA

CUMULATIVE				FUEL				NET DRIVE EFFICIENCY (%)	
HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	ENERGY LOSS (btu)	ENERGY USED (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)	(%)	
992.41	63769.32	21417.14	246106.20	3200.00	396.36	345.09	0.15		

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)
10400.00	575.95	3.54	162652.40	2360.66	755.88	339.75	15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. VEL.	MAX. LAT. ACCEL.	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	VELOCITY (mph)	(g's)	40 TON	AD-1000	CONSTANT	HoPol P-6
	45.00	0.50				

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	4	1000	31.3	0	75.76	4000	425.37	6.41	62.08

VEHICLE PERFORMANCE DATA

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)	
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	
9.00	27.91	0.000	335.01	113.31	15527.92	335.01	113.31	15527.92	67.02

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
999.65	53528.72	17651.26	3200.00	399.83	344.03	0.18
	299634.90					

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)
10400.00	2832.79	640.33	15.0	2832.79	640.33	345.37	15.0
BUSS VOLTAGE (volts)	CURRENT (amps)			VOLTAGE (volts)	CURRENT (amps)		
4.25	68307.50			4.25	68307.50		
GENERATOR POWER (Kw)							
580.50							
BUSS CURRENT (amps)							
136615.00							

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. LAT.	ENGINE	ELECTRIC
DATA INPUT BY USER	VELOCITY (mph)	SCHEDULING	DRIVE TYPE
	ACCEL. (g's)	CONSTANT	HoPol P-G
SURFACE	MAX. VELOCITY (mph)		
COMPACTED SOIL	45.00		
	0.50		
	40 TON		

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	5	1000	25.9	0	64.94	5000	490.31	6.96	72.62

VEHICLE PERFORMANCE DATA

INNER SPROCKET			OUTER SPROCKET			NET DRIVE	
FORWARD VELOCITY (mph)	LATERAL ACCELERATION (g's)	TRACTIVE EFFORT (K-lbs)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	EFFICIENCY (%)	
10.50	0.000	24.08	337.16	132.20	13395.19	67.61	

ENGINE / ENERGY DATA

HORSEPOWER GENERATED		SEGMENT ENERGY		CUMULATIVE ENERGY USED		ENGINE SPEED		FUEL CONSUMPTION		FUEL REMAINING		FUEL ECONOMY	
(hp)	(K-lbs)	(btu)	(K-lbs)	(btu)	(K-lbs)	(rpm)	(ft-lb)	(lb/hr)	(gal.)	(gal.)	(mpg)		
997.40	45778.49	345413.40	14828.73	3200.00	398.75	0.913	343.11	0.21					

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	10400.00	BUSS VOLTAGE (volts)	4.96	GENERATOR SPEED (rpm)	3304.92	BUSS VOLTAGE (volts)	4.96
GENERATOR POWER (Kw)	579.09	BUSS CURRENT (amps)	116813.20	GENERATOR TORQUE (ft-lb)	552.38	BUSS CURRENT (amps)	58406.58
				GENERATOR HORSEPOWER (hp)	347.59	FIELD POWER (Kw)	15.0
						FIELD POWER (Kw)	15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. LAT.	ENGINE	ELECTRIC
DATA INPUT BY USER	VELOCITY (mph)	AD-1000	DRIVE TYPE
	ACCEL. (g's)	CONSTANT	HoPol F-6
SURFACE	0.50		
COMPACTED SOIL	45.00		
	40 TON		

MISSION COURSE DATA

LAP NO. (#)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	22.1	0	56.82	6000	547.12	7.48	82.85

VEHICLE PERFORMANCE DATA

FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	INNER SPROCKET HORSEPOWER (hp)	INNER SPROCKET SPEED (rpm)	INNER SPROCKET TORQUE (ft-lb)	INNER SPROCKET HORSEPOWER (hp)	INNER SPROCKET SPEED (rpm)	INNER SPROCKET TORQUE (ft-lb)	NET DRIVE EFFICIENCY (%)
12.00	21.29	0.000	340.69	151.08	11843.66	340.69	151.08	11843.66	68.21

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
998.93	385531.00	12752.66	3200.00	399.49	342.31	0.24

ELECTRIC DRIVE DATA

GENERATOR				INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
SPEED (rpm)	POWER (Kw)	BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	VOLTAGE (volts)	CURRENT (amps)	VOLTAGE (volts)	CURRENT (amps)	FIELD POWER (Kw)
10400.00	580.05	5.67	102381.20	3777.05	488.40	351.23	5.67	51190.62	5.67	51190.62	15.0
											FIELD POWER (Kw)
											15.0

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MISSION PARAMETERS

COURSE

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LAP

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FORWARD

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GENERATE

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GENERATOR

***** ELECTRIC DRIVE PERFORMANCE *****

***** MISSION PARAMETERS *****

COURSE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	45.00	0.50	40 TON	AD-1000	CONSTANT	HoPol P-6
SURFACE	COMPACTED SOIL					

***** MISSION COURSE DATA *****

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	8	1000	16.8	0	45.45	8000	643.08	8.49	103.79

***** VEHICLE PERFORMANCE DATA *****

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)	
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	
15.00	17.29	0.000	345.95	188.85	9621.06	345.95	188.85	9621.06	69.39

***** ENGINE / ENERGY DATA *****

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL CONSUMED (gal.)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
997.08	32034.69	453143.20	9805.11	3200.00	398.60	0.639	340.97	0.30

***** ELECTRIC DRIVE DATA *****

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	VOLTAGE (volts)
10400.00	578.89	7.08	40870.45	4721.31	396.74	356.65	7.08
							CURRENT (amps)
							40870.45
							FIELD POWER (Kw)
							15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. LAT.	ENGINE	ELECTRIC
DATA INPUT BY USER	VELOCITY (mph)	SCHEDULING	DRIVE TYPE
COMPACTED SOIL	ACCEL. (g's)	CONSTANT	HoPol P-G
	45.00		
	0.50		
	40 TON		

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	9	1000	14.8	0	41.32	9000	684.41	8.97	114.02

VEHICLE PERFORMANCE DATA

FORWARD VELOCITY (mph)	16.50	TRACTIVE EFFORT (K-lbs)	15.76	LATERAL ACCELERATION (g's)	0.000	HORSEPOWER (hp)	346.80	TORQUE (ft-lb)	8767.86	SPEED (rpm)	207.74	HORSEPOWER (hp)	346.80	TORQUE (ft-lb)	8767.86	SPEED (rpm)	207.74	NET DRIVE EFFICIENCY (%)	69.49
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ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	998.18	SEGMENT ENERGY (btu)	29154.57	CUMULATIVE ENERGY USED (btu)	482297.70	SEGMENT ENERGY LOSS (btu)	8896.30	ENGINE SPEED (rpm)	3200.00	FUEL CONSUMPTION (lb/hr)	399.13	FUEL REMAINING (gal.)	340.38	FUEL ECONOMY (mpg)	0.33
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ELECTRIC DRIVE DATA

GENERATOR				INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR					
SPEED (rpm)	10400.00	POWER (Kw)	579.58	SPEED (rpm)	5193.44	TORQUE (ft-lb)	361.56	SPEED (rpm)	5193.44	TORQUE (ft-lb)	361.56	HORSEPOWER (hp)	357.52
BUS VOLTAGE (volts)	7.79	BUS CURRENT (amps)	74398.68	VOLTAGE (volts)	7.79	CURRENT (amps)	37199.34	VOLTAGE (volts)	7.79	CURRENT (amps)	37199.34	FIELD POWER (Kw)	15.0

***** ELECTRIC DRIVE PERFORMANCE *****

***** MISSION PARAMETERS *****

COURSE	MAX. VEL.	MAX. LAT. ACCEL.	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	VELOCITY (mph)	(g's)	40 TON	AD-1000	CONSTANT	HoPol P-6
	COMPACTED SOIL					

***** MISSION COURSE DATA *****

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	10	1000	13.1	0	37.88	10000	722.28	9.44	124.37

***** VEHICLE PERFORMANCE DATA *****

FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	NET DRIVE EFFICIENCY (%)
18.00	14.45	0.000	346.83	226.62	8037.85	346.83	226.62	8037.85	69.49

***** ENGINE / ENERGY DATA *****

HORSEPOWER GENERATED (hp)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
998.26	509024.70	8155.44	3200.00	399.16	339.85	0.36

***** ELECTRIC DRIVE DATA *****

GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	FIELD POWER (Kw)	CURRENT (amps)	VOLTAGE (volts)	FIELD POWER (Kw)																				
10400.00	579.62	8.50	68204.25	15.0	34102.13	8.50	15.0																				
				<table border="0"> <tr> <td colspan="2">INNER SPROCKET MOTOR</td> <td colspan="2">OUTER SPROCKET MOTOR</td> </tr> <tr> <td>SPEED (rpm)</td> <td>TORQUE (ft-lb)</td> <td>SPEED (rpm)</td> <td>TORQUE (ft-lb)</td> </tr> <tr> <td>5665.57</td> <td>331.46</td> <td>5665.57</td> <td>331.46</td> </tr> <tr> <td colspan="2">HORSEPOWER (hp)</td> <td colspan="2">HORSEPOWER (hp)</td> </tr> <tr> <td colspan="2">357.55</td> <td colspan="2">357.55</td> </tr> </table>				INNER SPROCKET MOTOR		OUTER SPROCKET MOTOR		SPEED (rpm)	TORQUE (ft-lb)	SPEED (rpm)	TORQUE (ft-lb)	5665.57	331.46	5665.57	331.46	HORSEPOWER (hp)		HORSEPOWER (hp)		357.55		357.55	
INNER SPROCKET MOTOR		OUTER SPROCKET MOTOR																									
SPEED (rpm)	TORQUE (ft-lb)	SPEED (rpm)	TORQUE (ft-lb)																								
5665.57	331.46	5665.57	331.46																								
HORSEPOWER (hp)		HORSEPOWER (hp)																									
357.55		357.55																									

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MISSION PARAMETERS*****

COURSE	SURFACE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	COMPACTED SOIL	45.00	0.50	40 TON	AD-1000	CONSTANT	HOPOI P-G

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*****
MISSION COURSE DATA
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LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	11	1000	11.65	0	34.97	11000	757.25	9.91	134.88

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*****
VEHICLE PERFORMANCE DATA
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FORWARD VELOCITY (mph)	TRACTION EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	INNER SPROCKET			OUTER SPROCKET			NET DRIVE EFFICIENCY (%)
			HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	
19.50	13.32	0.000	346.50	245.51	7412.52	346.50	245.51	7412.52	69.48

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*****
ENGINE / ENERGY DATA
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HORSEPOWER GENERATED	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL CONSUMED (gal.)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
997.38	24649.49	533674.20	7522.75	3200.00	398.74	0.491	339.36	0.39

ELECTRIC DRIVE DATA

GENERATOR		INNER SPROCKET MOTOR			OUTER SPROCKET MOTOR		
SPEED (rpm)	POWER (Kw)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)
10400.00	579.07	6137.71	305.67	357.21	6137.71	305.67	357.21
BUSS		FIELD POWER			FIELD POWER		
VOLTAGE (volts)	CURRENT (amps)	VOLTAGE (volts)	CURRENT (amps)	FIELD POWER (Kw)	VOLTAGE (volts)	CURRENT (amps)	FIELD POWER (Kw)
9.21	62898.09	9.21	31449.05	15.0	9.21	31449.05	15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	45.00	0.50	40 TON	AD-1000	CONSTANT	HoPol P-6

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	12	1000	10.4	0	32.47	12000	789.72	10.37	145.51

VEHICLE PERFORMANCE DATA

INNER SPROCKET			OUTER SPROCKET			NET DRIVE EFFICIENCY (%)
FORWARD VELOCITY (mph)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	TORQUE (ft-lb)	SPEED (rpm)	TORQUE (ft-lb)	
21.00	0.000	345.94	6872.08	264.39	6872.08	69.47

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
995.92	22855.12	556529.30	6977.07	3200.00	398.04	338.90	0.42

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)
10400.00	578.15	9.91	58312.26	6609.84	283.38	356.64	15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	45.00	0.50	40 TON	AD-1000	CONSTANT	HoPol P-G
SURFACE						
COMPACTED SOIL						

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	13	1000	9.38	0	30.30	13000	820.02	10.81	155.44

VEHICLE PERFORMANCE DATA

INNER SPROCKET				OUTER SPROCKET				NET DRIVE	
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	TORQUE (ft-lb)	SPEED (rpm)	HORSEPOWER (hp)	TORQUE (ft-lb)	TORQUE (ft-lb)	EFFICIENCY (%)
22.50	11.56	0.000	346.87	6431.04	283.28	346.87	6431.04	6431.04	69.49

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
998.37	21383.92	577913.30	6524.92	3200.00	399.22	338.48	0.44

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	TORQUE (ft-lb)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)
10400.00	579.69	10.62	54569.79	7081.97	7081.97	265.20	357.59
				FIELD POWER			
				VOLTAGE (volts)	CURRENT (amps)	VOLTAGE (volts)	CURRENT (amps)
				10.62	27284.90	10.62	27284.90
				FIELD POWER (Kw)			
				15.0			

***** ELECTRIC DRIVE PERFORMANCE *****

***** MISSION PARAMETERS *****

COURSE	MAX. VEL.	MAX. LAT.	ENGINE	ELECTRIC
DATA INPUT BY USER	VELOCITY (mph)	ACCEL. (g's)	SCHEDULING	DRIVE TYPE
COMPACTED SOIL	45.00	0.50	AD-1000	HoPol P-6
			CONSTANT	

***** MISSION COURSE DATA *****

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	14	1000	8.45	0	28.41	14000	848.43	11.26	165.81

***** VEHICLE PERFORMANCE DATA *****

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)	
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	(%)
24.00	10.84	0.000	346.85	302.16	6028.78	346.85	302.16	6028.78	69.49

***** ENGINE / ENERGY DATA *****

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR				FUEL ECONOMY (mpg)	
HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	TORQUE (ft-lb)	REMAINING (gal.)	(mpg)
998.32	20046.46	6116.87	3200.00	7554.10	248.61	357.58	248.61	338.08	0.47

***** ELECTRIC DRIVE DATA *****

GENERATOR				BUSS				FIELD POWER (Kw)			
SPEED (rpm)	POWER (Kw)	CURRENT (amps)	VOLTAGE (volts)	VOLTAGE (volts)	CURRENT (amps)	POWER (Kw)	VOLTAGE (volts)	CURRENT (amps)	POWER (Kw)	VOLTAGE (volts)	CURRENT (amps)
10400.00	579.66	51156.53	11.33	11.33	25578.27	15.0	11.33	25578.27	15.0	11.33	25578.27

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	SURFACE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	COMPACTED SOIL	45.00	0.50	40 TON	AD-1000	CONSTANT	HoPol P-G

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	15	1000	7.65	0	26.74	15000	875.17	11.69	175.86

VEHICLE PERFORMANCE DATA

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)	
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	EFFICIENCY (%)
25.50	10.22	0.000	347.41	321.05	5683.37	347.41	321.05	5683.37	69.50

ENGINE / ENERGY DATA

ENGINE				FUEL CONSUMED		FUEL REMAINING		FUEL ECONOMY (mpg)	
HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	CONSUMPTION (lb/hr)	(gal.)	(gal.)	(mpg)	(mpg)	(mpg)
999.82	18895.57	5764.06	3200.00	399.91	0.377	337.70	0.50	0.50	0.50

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR					
GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	INNER SPROCKET SPEED (rpm)	INNER SPROCKET TORQUE (ft-lb)	INNER SPROCKET HORSEPOWER (hp)	OUTER SPROCKET SPEED (rpm)	OUTER SPROCKET TORQUE (ft-lb)	OUTER SPROCKET HORSEPOWER (hp)
10400.00	580.60	12.04	48225.57	8026.23	234.37	358.16	8026.23	234.37	358.16

FIELD POWER			
VOLTAGE (volts)	CURRENT (amps)	POWER (Kw)	FIELD POWER (Kw)
12.04	24112.79	15.0	15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	45.00	0.50	40 TON	AD-1000	CONSTANT	HoPol P-G
SURFACE						
COMPACTED SOIL						

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	16	1000	6.88	0	25.25	16000	900.42	12.12	186.85

VEHICLE PERFORMANCE DATA

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	TORQUE (ft-lb)	SPEED (rpm)	HORSEPOWER (hp)	TORQUE (ft-lb)	
27.00	9.62	0.000	346.34	5351.01	339.93	346.34	5351.01	69.48

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
996.96	17794.81	634650.10	5431.21	3200.00	398.54	337.35	0.53

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)
10400.00	578.81	8498.36	357.05	8498.36	220.66	357.05	15.0
BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	VOLTAGE (volts)	FIELD POWER (Kw)	VOLTAGE (volts)	CURRENT (amps)	FIELD POWER (Kw)	
12.75	45405.39	12.75	15.0	12.75	22702.70	15.0	

***** ELECTRIC DRIVE PERFORMANCE *****

***** MISSION PARAMETERS *****

COURSE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	45.00	0.50	40 TON	AD-1000	CONSTANT	HoPol P-G
SURFACE	COMPACTED SOIL					

***** MISSION COURSE DATA *****

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	17	1000	6.25	0	23.92	17000	924.34	12.55	196.75

***** VEHICLE PERFORMANCE DATA *****

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)	
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	
28.50	9.13	0.000	347.10	358.82	5080.51	347.10	358.82	5080.51	69.49

***** ENGINE / ENERGY DATA *****

GENERATOR			SEGMENT			FUEL			FUEL ECONOMY		
HORSEPOWER GENERATED (hp)	ENERGY (btu)	LOSS (btu)	ENERGY USED (btu)	ENGINE SPEED (rpm)	CONSUMPTION (lb/hr)	CONSUMED (gal.)	REMAINING (gal.)				
998.98	16892.40	5153.81	651542.50	3200.00	399.51	0.337	337.01				0.56

***** ELECTRIC DRIVE DATA *****

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	POWER (Kw)	BUSS VOLTAGE (volts)	CURRENT (amps)	GENERATOR SPEED (rpm)	POWER (Kw)	BUSS VOLTAGE (volts)	CURRENT (amps)
10400.00	580.08	43110.04	43110.04	8970.49	580.08	43110.04	43110.04
				TORQUE (ft-lb)	357.83	TORQUE (ft-lb)	357.83
				HORSEPOWER (hp)	357.83	HORSEPOWER (hp)	357.83
				VOLTAGE (volts)	13.46	VOLTAGE (volts)	13.46
				CURRENT (amps)	21555.02	CURRENT (amps)	21555.02
				FIELD POWER (Kw)	15.0	FIELD POWER (Kw)	15.0

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ELECTRIC
DRIVE TYPE

✻
✻
✻
✻

RANGE ESTIMATE

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NET DETIVE

FUEL ECONOMY

◆◆◆◆◆

OTOR

◆◆◆◆◆

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ELECTRIC
DRIVE TYPE
Hofo1 P-G

◆◆◆◆◆

RANGE
ESTIMATE
(miles)
217.88

✻
✻
✻
✻

NET DRIVE
EFFICIENCY
(%)
69.48

— 36 —

**FUEL
ECONOMY**
(mpg)
0.62

✻
✻
✻
✻

MOTOR

 HORSEPOWER
 (hp)
 357.21

FIELD POWER
 (Kw)
 15.0

***** ELECTRIC DRIVE PERFORMANCE *****

***** MISSION PARAMETERS *****

COURSE	MAX. VEL.	MAX. LAT.	ENGINE	ELECTRIC
DATA INPUT BY USER	VELOCITY (mph)	ACCEL. (g's)	SCHEDULING	DRIVE TYPE
COMPACTED SOIL	45.00	0.50	AD-1000	HoPol P-G
			CONSTANT	

***** MISSION COURSE DATA *****

LAP NO.	SEGMENT NO.	DISTANCE	GRADE	RADIUS	TIME	CUMULATIVE	AVG. FORWARD	RANGE
(#)	(#)	(ft)	(%)	(ft)	(sec)	DISTANCE (ft)	VELOCITY (mph)	ESTIMATE (miles)
1	20	1000	4.63	0	20.66	20000	13.79	227.71

***** VEHICLE PERFORMANCE DATA *****

INNER SPROCKET				OUTER SPROCKET				NET DRIVE
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	EFFICIENCY (%)
33.00	7.89	0.000	347.25	415.48	4389.58	347.25	415.48	69.49

***** ENGINE / ENERGY DATA *****

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
999.37	14594.63	4452.44	3200.00	399.70	336.09	0.65

***** ELECTRIC DRIVE DATA *****

GENERATOR				INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
SPEED (rpm)	POWER (Kw)	BUSS VOLTAGE (volts)	CURRENT (amps)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)
10400.00	580.33	15.58	37247.27	10386.90	181.01	357.98	15.0	10386.90	181.01	357.98	15.0

✱✱✱✱

— — — — —

ELECTRIC
DRIVE TYPE
HoPol P-G

CUMULAT
TIME
(sec)
1009.14

✱ ✱ ✱ ✱

SPEED
(rpm)
434.36

TORQUE
(ft-lb)
4195.27

✽ ✽ ✽ ✽

FUEL
CONSUMED
(gal.)
0.278

FUEL
REMAINING
(gal.)
335.82

其其其其

SPEED
(rpm)
10859.

HORSEPOWER
(hp)
357.69

VOLTAGE
(volts)
16.29

FIELD POWER
(Kw)
15.0

●●●●

DATA INPUT BY USER

✻
✻
✻
✻

LAF

FORWARD

❖ ❖ ❖ ❖

GENERATE

◆◆◆◆◆

SEED

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. LAT.	ENGINE	ELECTRIC
SURFACE	ACCEL.	SCHEDULING	DRIVE TYPE
COMPACTED SOIL	(g's)	CONSTANT	HoPol P-G
	45.00		

MISSION COURSE DATA

LAP NO.	GRADE	CUMULATIVE	AVG. FORWARD	RANGE
(#)	(%)	DISTANCE	VELOCITY	ESTIMATE
1	3.38	(ft)	(mph)	(miles)
		23000	15.00	258.57

VEHICLE PERFORMANCE DATA

FORWARD	INNER SPROCKET		OUTER SPROCKET		NET DRIVE
VELOCITY	LATERAL	HORSEPOWER	TORQUE	SPEED	EFFICIENCY
(mph)	ACCELERATION	(hp)	(ft-lb)	(rpm)	(%)
37.50	(g's)	347.48	3865.40	472.13	69.50
	0.000			3865.40	

ENGINE / ENERGY DATA

HORSEPOWER	SEGMENT	ENGINE	FUEL	FUEL	FUEL
GENERATED	ENERGY LOSS	SPEED	CONSUMPTION	REMAINING	ECONOMY
(hp)	(btu)	(rpm)	(lb/hr)	(gal.)	(mpg)
999.99	12851.15	3200.00	399.99	335.29	0.74
			0.256		

ELECTRIC DRIVE DATA

GENERATOR		INNER SPROCKET MOTOR		OUTER SPROCKET MOTOR	
SPEED	POWER	SPEED	TORQUE	SPEED	TORQUE
(rpm)	(Kw)	(rpm)	(ft-lb)	(rpm)	(ft-lb)
10400.00	580.71	11803.30	159.40	11803.30	159.40
					358.22
BUSS	BUSS	VOLTAGE	CURRENT	VOLTAGE	CURRENT
VOLTAGE	CURRENT	(volts)	(amps)	(volts)	(amps)
(volts)	(amps)	17.70	16399.69	17.70	16399.69
17.70	32799.37				
		FIELD POWER		FIELD POWER	
		(Kw)		(Kw)	
		15.0		15.0	

***** ELECTRIC DRIVE PERFORMANCE *****

***** MISSION PARAMETERS *****

COURSE	MAX. VEL.	MAX. LAT.	ENGINE	ENGINE	ELECTRIC
DATA INPUT BY USER	VELOCITY (mph)	ACCEL. (g's)	VEHICLE	SCHEDULING	DRIVE TYPE
COMPACTED SOIL	45.00	0.50	40 TON	CONSTANT	HoPol P-8

***** MISSION COURSE DATA *****

LAP NO. (#)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	3	0	17.48	24000	1063.74	15.39	269.64

***** VEHICLE PERFORMANCE DATA *****

FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	NET DRIVE EFFICIENCY (%)
39.00	6.66	0.000	346.63	491.02	3707.67	69.48

***** ENGINE / ENERGY DATA *****

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
997.74	12329.07	749927.80	3762.44	3200.00	398.91	335.05	0.77

***** ELECTRIC DRIVE DATA *****

GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	FIELD POWER (Kw)	CURRENT (amps)	VOLTAGE (volts)	FIELD POWER (Kw)
10400.00	579.30	18.41	31461.01	15.0	15730.50	18.41	15.0

INNER SPROCKET MOTOR	OUTER SPROCKET MOTOR
SPEED (rpm)	SPEED (rpm)
12275.43	12275.43
TORQUE (ft-lb)	TORQUE (ft-lb)
152.89	152.89
HORSEPOWER (hp)	HORSEPOWER (hp)
357.35	357.35

***** ELECTRIC DRIVE PERFORMANCE *****

***** MISSION PARAMETERS *****

COURSE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	45.00	0.50	40 TON	AD-1000	CONSTANT	HoPol P-G
SURFACE						
COMPACTED SOIL						

***** MISSION COURSE DATA *****

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	25	1000	2.67	0	16.83	25000	1080.58	15.78	279.82

***** VEHICLE PERFORMANCE DATA *****

INNER SPROCKET				OUTER SPROCKET				NET DRIVE EFFICIENCY (%)
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	SPEED (rpm)	TORQUE (ft-lb)
40.50	6.42	0.000	346.84	509.90	3572.56	346.84	509.90	3572.56
								69.49

***** ENGINE / ENERGY DATA *****

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
998.30	11879.21	761807.00	3624.77	3200.00	399.19	334.81	0.80

***** ELECTRIC DRIVE DATA *****

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)
10400.00	579.65	19.12	30314.50	12747.56	147.32	357.57	15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE DATA INPUT BY USER SURFACE COMPACTED SOIL MAX. VELOCITY (mph) 45.00 MAX. LAT. ACCEL. (g's) 0.50 VEHICLE 40 TON ENGINE AD-1000 SCHEDULING CONSTANT ELECTRIC DRIVE TYPE HoPol P-6

MISSION COURSE DATA

LAP NO. (#) 1 SEGMENT NO. (#) 26 DISTANCE (ft) 1000 GRADE (%) 2.37 RADIUS (ft) 0 TIME (sec) 16.23 CUMULATIVE DISTANCE (ft) 26000 CUMULATIVE TIME (sec) 1096.81 AVG. FORWARD VELOCITY (mph) 16.17 RANGE ESTIMATE (miles) 289.60

VEHICLE PERFORMANCE DATA

FORWARD VELOCITY (mph) 42.00 TRACTIVE EFFORT (k-lbs) 6.20 LATERAL ACCELERATION (g's) 0.000 HORSEPOWER (hp) 347.47 TORQUE (ft-lb) 3451.18 SPEED (rpm) 528.79 FUEL CONSUMPTION (gal.) 0.229 FUEL REMAINING (gal.) 334.58 FUEL ECONOMY (mpg) 0.83 NET DRIVE EFFICIENCY (%) 69.50

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp) 999.97 SEGMENT ENERGY (btu) 11474.03 CUMULATIVE ENERGY USED (btu) 773281.00 SEGMENT ENERGY LOSS (btu) 3500.03 ENGINE SPEED (rpm) 3200.00 FUEL CONSUMPTION (lb/hr) 399.98

ELECTRIC DRIVE DATA

GENERATOR SPEED (rpm) 10400.00 GENERATOR POWER (Kw) 580.70 BUSS VOLTAGE (volts) 19.83 BUSS CURRENT (amps) 29284.57 FIELD POWER (Kw) 15.0 FIELD POWER (Kw) 15.0

ELECTRIC DRIVE PERFORMANCE

MISSION PARAMETERS

COURSE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
DATA INPUT BY USER	45.00	0.50	40 TON	AD-1000	CONSTANT	HoPol P-S

MISSION COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	27	1000	2.06	0	15.67	27000	1112.49	16.56	300.59

VEHICLE PERFORMANCE DATA

INNER SPROCKET				OUTER SPROCKET		NET DRIVE EFFICIENCY (%)
FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	TORQUE (ft-lb)	SPEED (rpm)	
43.50	5.98	0.000	346.80	3325.76	547.67	69.49

ENGINE / ENERGY DATA

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
998.19	11058.69	784339.70	3374.47	3200.00	399.13	0.221	0.86

ELECTRIC DRIVE DATA

INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (Kw)
10400.00	579.58	20.54	28220.36	13691.81	137.14	357.53	15.0

***** ELECTRIC DRIVE PERFORMANCE *****

***** MISSION PARAMETERS *****

COURSE	MAX. LAT.	ENGINE	ELECTRIC
DATA INPUT BY USER	ACCEL. (g's)	SCHEDULING	DRIVE TYPE
SURFACE	VELOCITY (mph)	AD-1000	HoPol P-G
COMPACTED SOIL	0.50	CONSTANT	

***** MISSION COURSE DATA *****

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	28	1000	1.75	0	15.15	28000	1127.64	16.94	312.47

***** VEHICLE PERFORMANCE DATA *****

FORWARD VELOCITY (mph)	TRACTIVE EFFORT (K-lbs)	LATERAL ACCELERATION (g's)	INNER SPROCKET	OUTER SPROCKET	NET DRIVE EFFICIENCY (%)
45.00	5.75	0.000	HORSEPOWER (hp)	SPEED (rpm)	69.46
			345.27	566.56	
			3200.76	3200.76	

B-194

***** ENGINE / ENERGY DATA *****

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
994.13	10646.64	794986.30	3251.25	3200.00	397.18	334.15	0.89

***** ELECTRIC DRIVE DATA *****

GENERATOR SPEED (rpm)	GENERATOR POWER (Kw)	INNER SPROCKET MOTOR	OUTER SPROCKET MOTOR	FIELD POWER (Kw)
10400.00	577.03	SPEED (rpm)	SPEED (rpm)	15.0
		14163.94	14163.94	
		TORQUE (ft-lb)	TORQUE (ft-lb)	
		131.99	131.99	
		HORSEPOWER (hp)	HORSEPOWER (hp)	
		355.95	355.95	
BUSS VOLTAGE (volts)	BUSS CURRENT (amps)	VOLTAGE (volts)	CURRENT (amps)	FIELD POWER (Kw)
21.25	27159.65	21.25	13579.82	15.0

APPENDIX C

CONFIGURATION III ANALYSIS

Title: CONFIGURATION III ANALYSIS

I. INTRODUCTION

FOR THE PURPOSE OF THIS ANALYSIS THE FINAL DRIVES ARE ASSUMED TO BE A CONVENTIONAL ARRANGEMENT OF SPUR REDUCTION GEARS COMBINED WITH A PLANETARY SECTION TO SUM THE PROPULSION AND STEER INPUTS.

THE APPROACH USED IS AS FOLLOWS :

- BRIEF DISCUSSION OF CONFIGURATION III
- GEAR AND POWER FLOW ANALYSIS
 - ASSUMPTIONS/BACKGROUND
 - ARRANGEMENT OF COMBINING PLANETARY
 - ARRANGEMENT #1
 - GEARING
 - POWER FLOW SCHEMATIC
 - ARRANGEMENT #2
 - GEARING
 - POWER FLOW SCHEMATIC
- RESULTS

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K. HIRATA	2 JULY 84	
R. GRIFFITHS		
H. CROFT		

C-2

es	Date of Signature	Date Understood

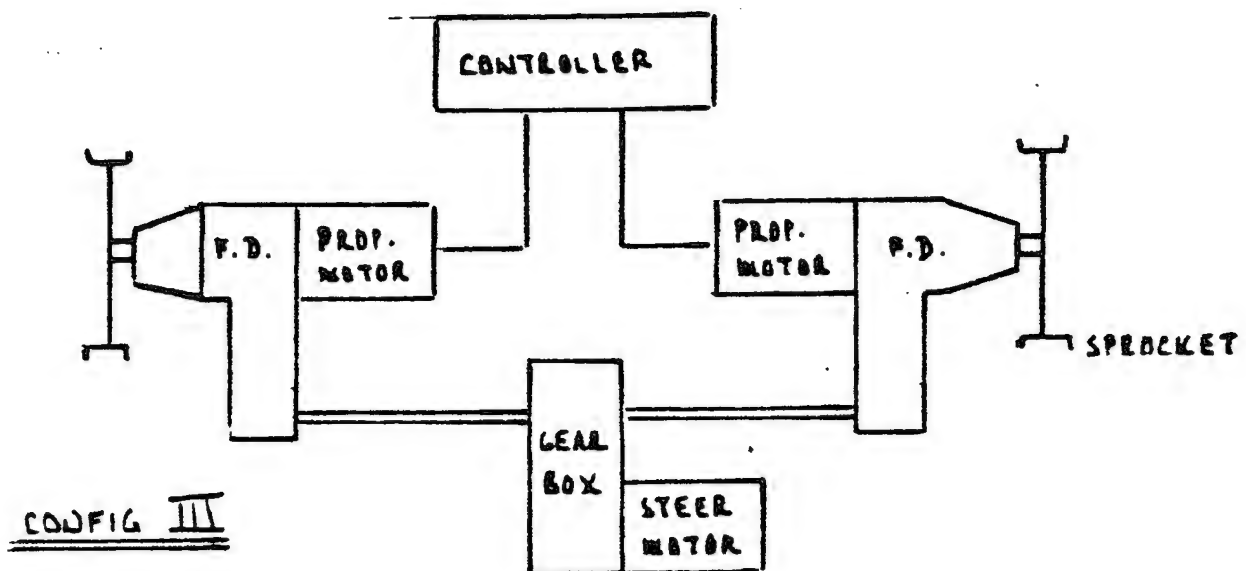
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2. DISCUSSION OF CONFIGURATION III

IN ORDER FOR CONFIGURATION III TO FUNCTION :

- a) BOTH PROPULSION MOTORS MUST OPERATE AT IDENTICAL SPEEDS AND THUS CONTROL THE AVERAGE VEHICLE SPEED.
- b) THE STEER MOTOR CONTROLS STEERING ONLY.
- c) THE FINAL DRIVES MUST HAVE SOME TYPE OF COMBINING PLANETARY.

A SKETCH OF THIS CONFIGURATION APPEARS BELOW:



Title: _____

3. GEAR AND POWER FLOW ANALYSIS

THE FOLLOWING ANALYSIS IS TYPICAL FOR A PLANETARY GEAR SET BASED ON MATHEMATICAL PROCEDURES AND PLANETARY GEAR SET OPERATION.

a) ASSUMPTIONS / BACKGROUND :

SYMBOLS USED

$T \equiv$ TORQUE

$\omega \equiv$ ANGULAR VELOCITY

$N \equiv$ NO. OF TEETH

SUBSCRIPTS

$S =$ SUN GEAR

$I =$ INTERNAL GEAR

$C =$ CAGE

SIGN CONVENTION

INPUT HP = + , OUTPUT HP = -

\therefore INPUT SPEED AND TORQUE WILL HAVE THE SAME SIGN AND OUTPUT SPEED AND TORQUE WILL HAVE OPPOSITE SIGN. $\sum T = 0$. (PROOF @ P. C-10)

TORQUE RELATIONSHIP

$$T_S = - \frac{T_C}{1+M} \quad \text{WHERE } M = \frac{N_I}{N_S}$$

$$T_I = - \frac{M}{1+M} T_C \quad \therefore T_S + T_I = -T_C$$

b) ARRANGEMENT OF COMBINING PLANETARY :

TWO ARRANGEMENTS WERE ANALYZED AS FOLLOWS

	# 1	# 2
CAGE	OUTPUT	
INTERNAL GEAR	PROP. MOTOR	STEER MOTOR
SUN GEAR	STEER MOTOR	PROP. MOTOR

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C-4

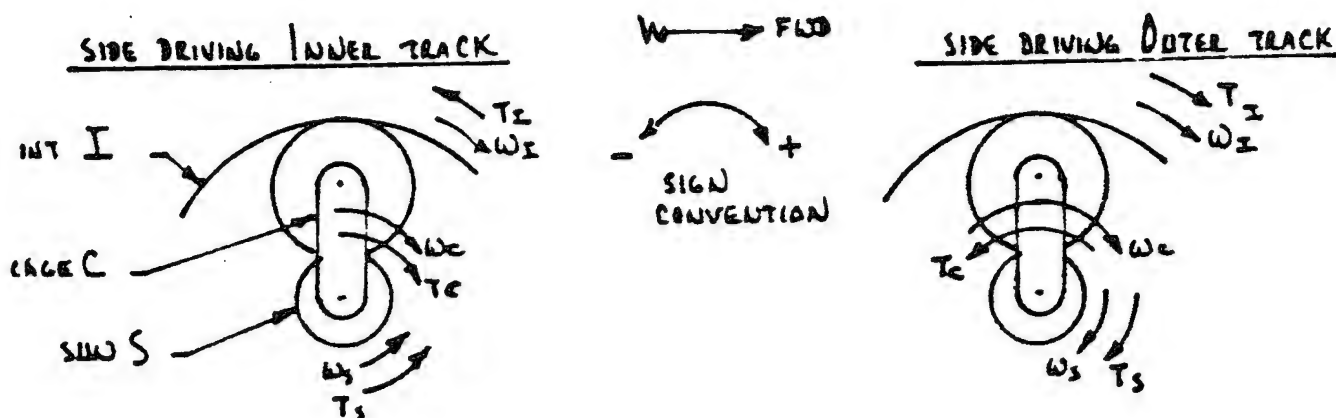
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ANALYSIS OF THESE ARRANGEMENTS PROVIDE THE BACKGROUND FROM WHICH CONFIGURATION III POWER FLOW ANALYSIS CAN BE DERIVED. ARRANGEMENT #1 IS ANALYZED FIRST FOR GEARING AND POWER FLOW; THEN ARRANGEMENT #2.

d) ARRANGEMENT #1 (INTERNAL = PROP. MOTOR, SUN = STEER MOTOR, CAGE = OUTPUT)

GEARING



- SINCE THE SUN GEARS ARE DRIVEN BY THE STEER MOTOR, THEY MUST HAVE OPPOSING SPEEDS AS SHOWN ABOVE TO SLOW DOWN INNER TRACK AND SPEED UP OUTER TRACK.
- BY DEFINITION (PAGE 3) AT THE INNER TRACK SIDE, T_c & w_c ARE SAME SIGN (BECAUSE OF REGENERATIVE HP FLOWING INTO UNIT FROM TRACKS). AT OUTER TRACK SIDE, THE SIGNS OPPOSE BECAUSE HP IS FLOWING OUT OF UNIT.
- FROM TORQUE RELATIONSHIP (PAGE 3), BOTH SUN TORQUE, T_s & INTERNAL GEAR TORQUE, T_i MUST BE OF OPPOSITE SIGN FROM CAGE TORQUE, T_c , SHOWN ABOVE.
- THE SIGNS OF SPEED, w ; TORQUE, T & ; HP WILL THEN BE :

	INNER TRACK			OUTER TRACK		
	I	S	C	I	S	C
	PROP MOTOR	STEER MOTOR	OUTPUT	PROP MOTOR	STEER MOTOR	OUTPUT
w	+	-	+	+	+	+
T	-	-	+	+	+	-
HP	-	+	+	+	+	-

SEE SIGN CONVENTION
 PREVIOUS PAGE: - = OUT, + = IN

Title:

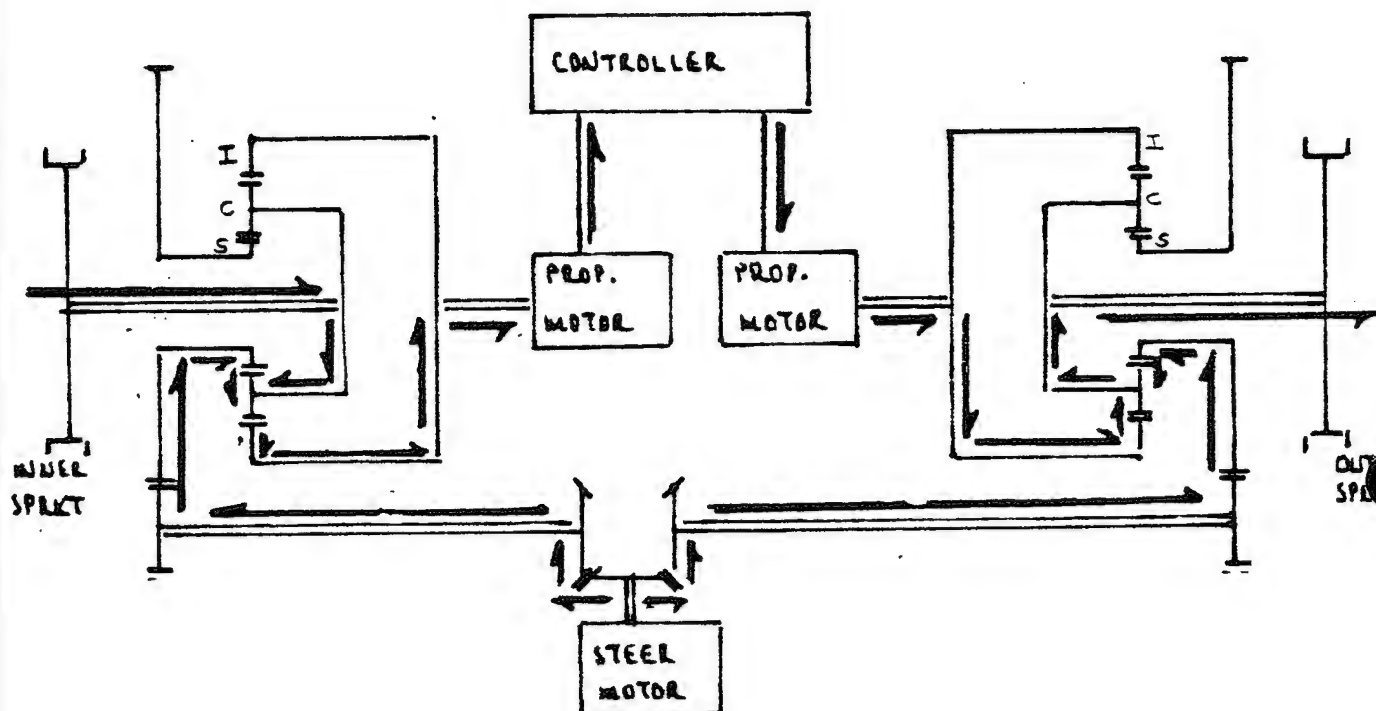
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POWER FLOW SCHEMATIC

REGENERATIVE HP FLOWS INTO THE PROPULSION MOTOR AND NOT THROUGH THE STEER CONTROL SHAFT.



↓ FORWARD
↘ STEER DIRECTION

C-6

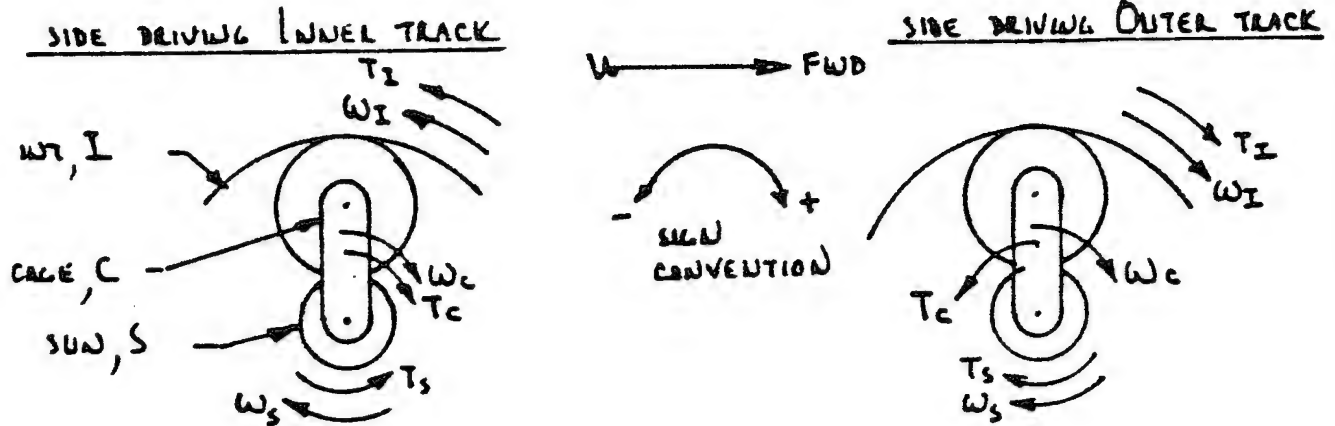
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E) ARRANGEMENT #2 (INTERNAL = STEER MOTOR, SUN = PROP MOTOR, CAGE = OUTPUT)

GEARING



- SINCE THE INTERNAL GEARS ARE DRIVEN BY THE STEER MOTOR, THEY MUST HAVE OPPOSING SPEEDS AS SHOWN ABOVE.
- THE SIGNS OF THE TORQUE WILL BE THE SAME AS FOR ARRANGEMENT #1.
- THE SIGNS OF W , T , HP WILL THEN BE :

	INNER TRACK			OUTER TRACK		
	I	S	C	I	S	C
	STEER MOTOR	PROP MOTOR	OUTPUT	STEER MOTOR	PROP MOTOR	OUTPUT
W	-	+	+	+	+	+
T	-	-	+	+	+	-
HP	+	-	+	+	+	-

▲ SEE SIGN CONVENTION ON PAGE 3 : - = OUT , + = IN

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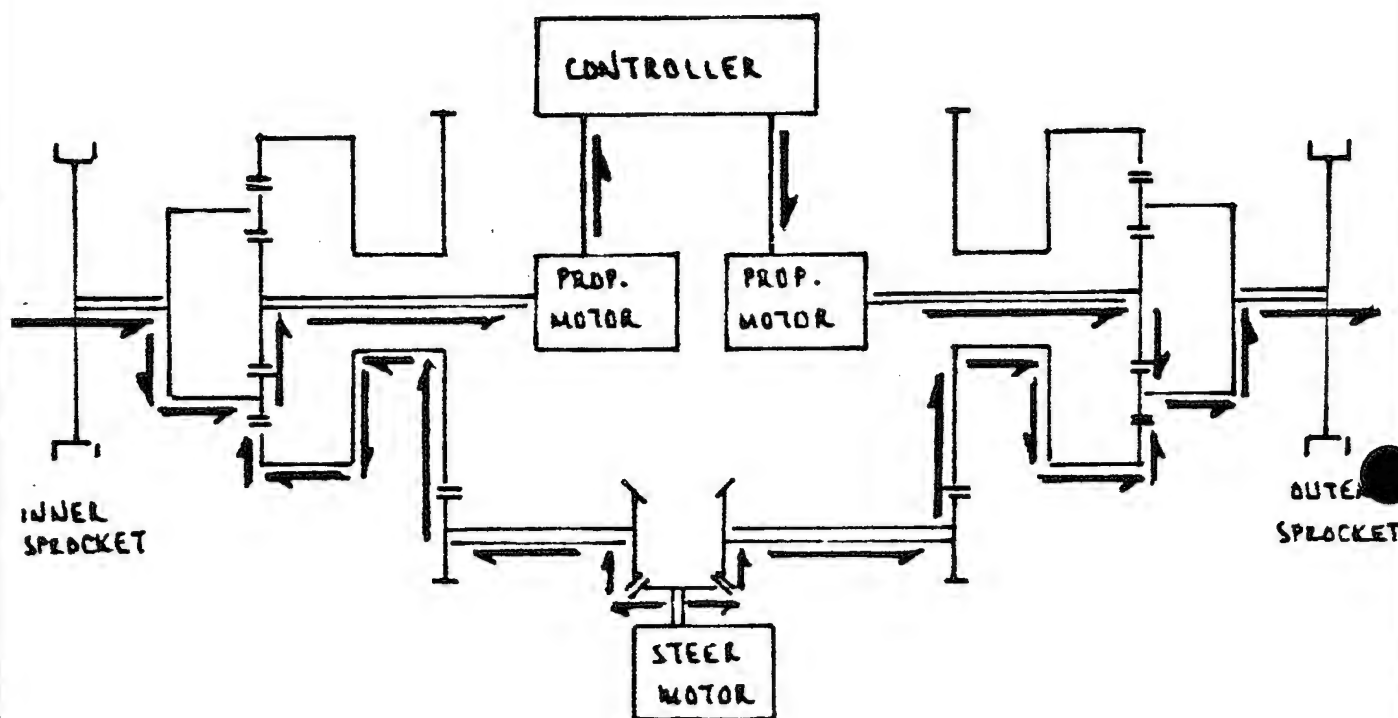
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POWER FLOW SCHEMATIC

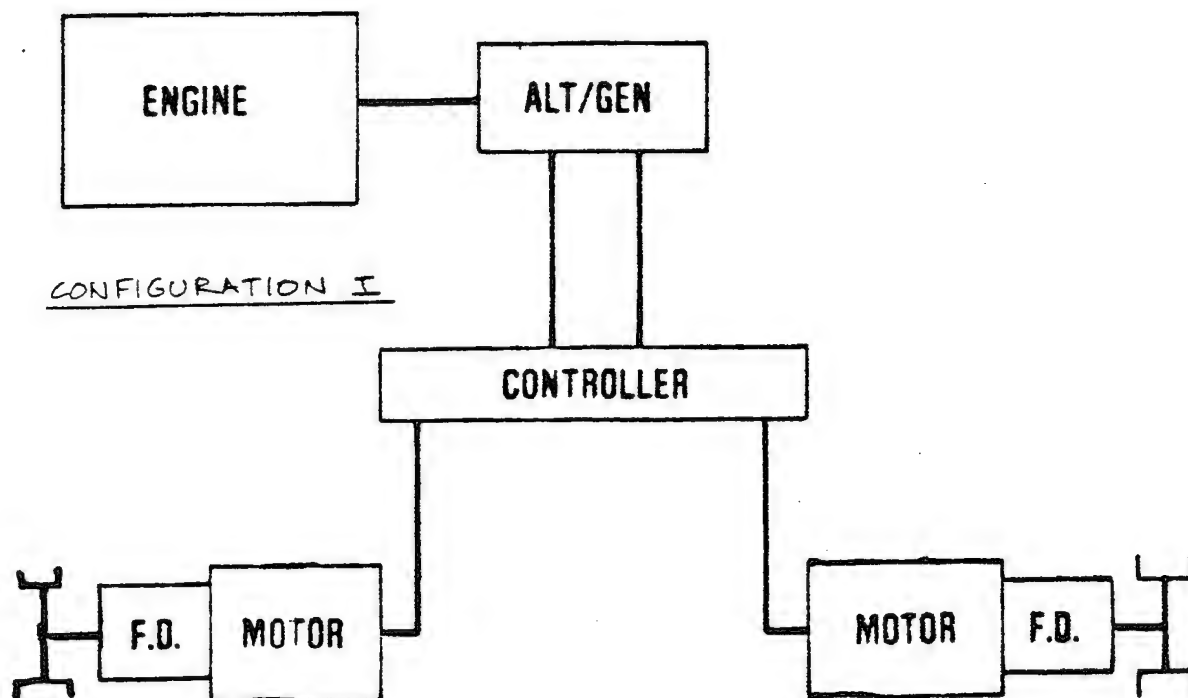
REGENERATIVE HP FLOWS INTO THE PROPULSION MOTOR, AND NOT THROUGH THE STEER CONTROL SHAFT.



Title: _____

4. RESULTS

- IN BOTH ARRANGEMENTS , THE POWER FLOW IS INTO THE PROPULSION MOTOR (FROM STEERING REGENERATION)
- BECAUSE REGENERATED POWER FLOW IS THRU INNER TRACK PROPULSION MOTOR TO CONTROLLER TO OUTER TRACK PROPULSION MOTOR , MOTORS AND CONTROLLER MUST BE SIZED TO TRANSFER REGENERATIVE LOADS. THIS IS THE SAME MANNER IN WHICH CONFIGURATION I OPERATES (SHOWN BELOW)



- IT IS THE FUNCTION OF THE PROPULSION SYSTEM TO TRANSFER POWER EFFICIENTLY, BUT CONFIGURATION III HAS THE BURDEN OF CARRYING A STEER MOTOR AND SHAFTING TO ACCOMPLISH THE SAME TRANSFER THAT CONFIGURATION I CARRIES OUT. A SUMMARY OF THIS FACT IS ON THE NEXT PAGE.

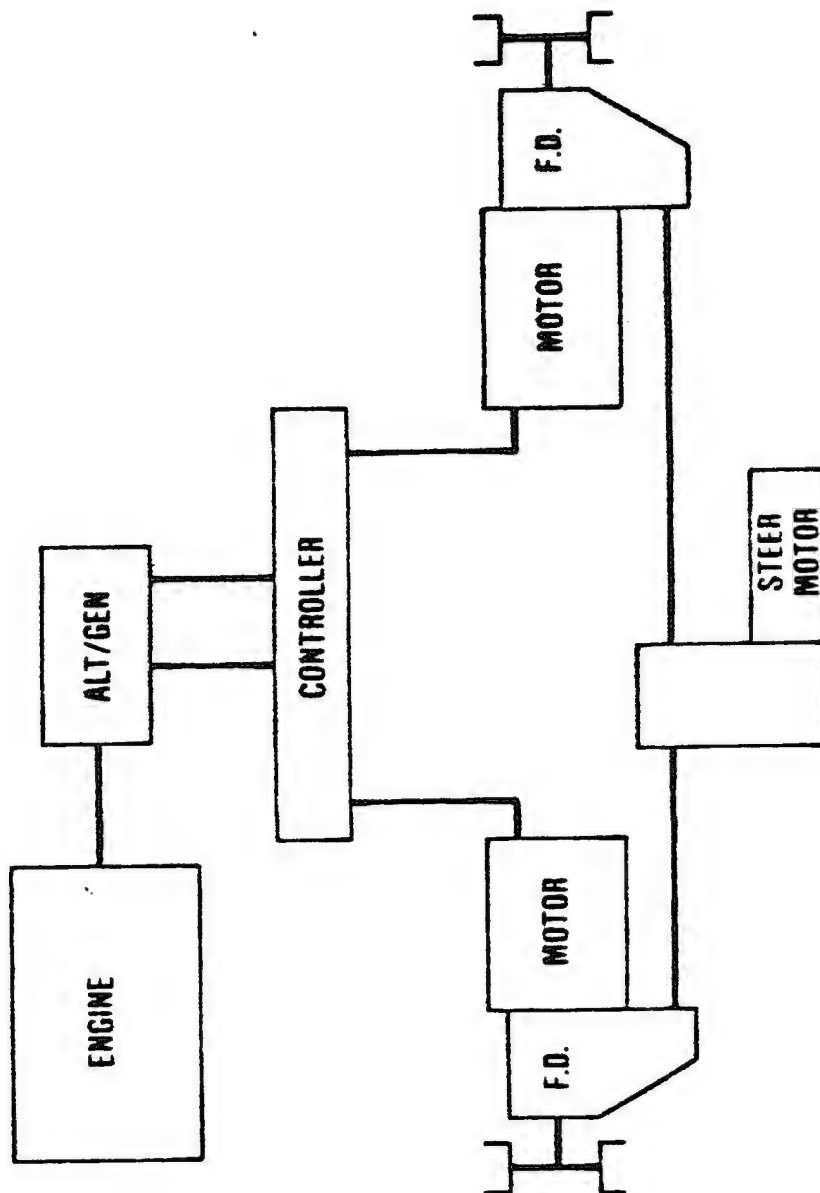
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Configuration III



Detailed analysis shows regenerative HP flow is through the propulsion motors
 ∴ This arrangement has no advantage over Configuration I

C-10

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Title: SIGN OF INT & SUN TORQUE

Division: _____
Project: _____
Page 1 of 4

DISCUSSION

IN A COMBINING PLANETARY, WHEN WE APPLY THE SIGN CONVENTION FOR I/P (IE $+$ = INPUT, $-$ = OUTPUT) WE FIND THAT THE SUN & INT TORQUE MUST HAVE THE SAME SENSE (IE POSITIVE OR NEGATIVE SIGN)

WE WILL PROVE THE ABOVE PT. IN THE FOLLOWING ANALYSIS

CONVENTION

INPUT I/P = $+$

OUTPUT I/P = $-$

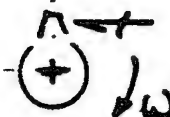
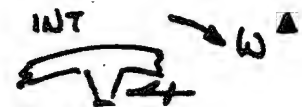
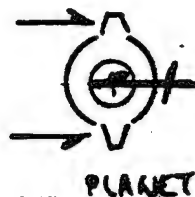
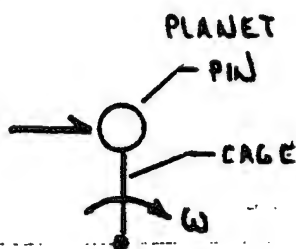
\rightarrow = APPLIED FORCE

\leftarrow = REACTION FORCE

\curvearrowright = $+\omega$

I A CAGE = OUTPUT

(PLANET TOOTH LOADS BOTH ARE "APPLY")



	INT	SUN
FORCES	REACTIVE	REACTIVE
DRIVE R OR N	DRIVER	DRIVE R
I/P SIGN	$+$	$+$
ω SIGN	$+$	$+$
TORQUE SIGN	$+$	$+$

▲ ROTATION IS OPPOSITE TO DIRECTION OF REACTIVE FORCE

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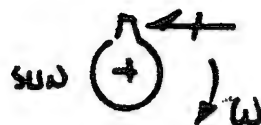
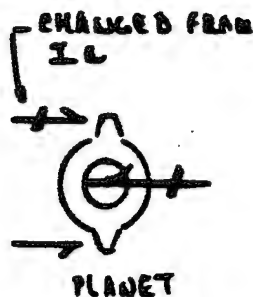
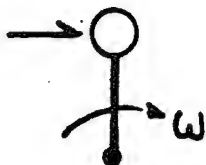
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Title: SIGN OF INT & SUN TORQUE

Division: _____
Project: _____
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Ib PAGE = OUTPUT

(PLANET TOOTH LOADS APPLY : REACTIVE)

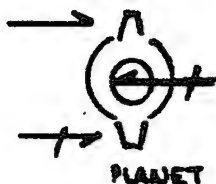
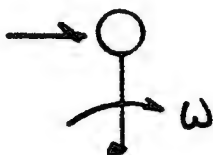


	INT	SUN
FORCES	APPLY	REACTIVE
DRIVE OR N	DRIVE N	DRIVE R
INT SIGN	-	+
ω SIGN	-	+
TORQUE SIGN	+	+

■ ROTATION IS IN SAME DIRECTION AS APPLY FORCE

Ib CAGE = OUTPUT

(APPLY : REACTIVE FORCES)
(SWAPPED FROM I b)



	INT	SUN
FORCES	REACTIVE	APPLY
DRIVE R OR N	DRIVE R	DRIVE N
INT SIGN	+	-
ω SIGN	+	-
TORQUE SIGN	+	+

Signature VN Date of Signature 29 APR 85

C-12

Drawn _____ Date of Signature _____ Date Understood _____

This: SIGN OF INT. : SUN TORQUE

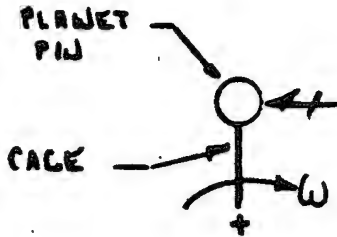
Division: _____

Project: _____

Page 3 of _____

II a CAGE = INPUT

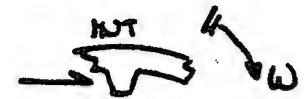
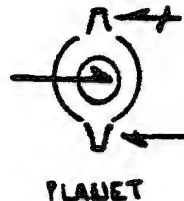
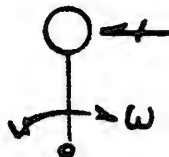
(BOTH PLANET LOADS ARE REACTIVE)



	INT	SUN
FORCES	APPLY	APPLY
DRIVER OR DRIVEN	DRIVE N	DRIVE N
W SIGN	—	—
TORQUE SIGN	+	+

II b CAGE = INPUT

(PLANET TOOTH LOADS ARE APPLY : REACTIVE)



	INT	SUN
FORCES	APPLY	REACTIVE
DRIVE R or N	DRIVE N	DRIVE R
W SIGN	—	+
TORQUE SIGN	+	—

C-13

Signature: ICM Date of Signature: 29 Apr 85

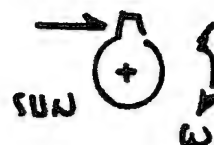
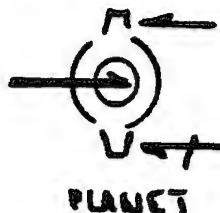
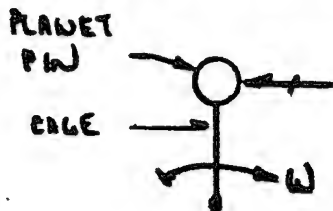
Signature: _____ Date of Signature: _____ Date Understood: _____

Title: SIGN OF INT & SUN TORQUE

Division: _____
Project: _____
Page 4 of 4

II C CAGE = INPUT

(PLANET TOOTH LOADS
SWAPPED FROM II b)



	INT	SUN
FORCES	REACTIVE	APPLY
DRIVE R OR N	DRIVE R	DRIVE N
UP SIGN	+	-
W SIGN	-	+
TORQUE SIGN	-	-

CONCLUSION

THERE ARE 6 POSSIBLE COMBINATIONS OF SUN & INT TORQUE AS SHOWN IN THE PRECEDING ANALYSIS. IN ALL 6 CASES, THE SIGN OF THE TORQUE ARE THE SAME (IE BOTH POSITIVE OR BOTH NEGATIVE)

Signature: WJ Date of Signature: 29 APR 85

C-14

Picture: _____ Date of Signature: _____ Date Understood: _____

APPENDIX D

CONFIGURATION IV ANALYSIS

Appendix D Configuration IV Analysis

The information in this appendix supplements the discussion in Section 5.2.6 in the main body of the report.

CVX 650 POWER
FLOW ANALYSIS

Title: XHM 650 TOUT : HP

Division: _____
Project: _____
Page 1 of 3

DISCUSSION

FROM ALLISON TABULATION OF SPDS : PARTIAL TABULATION
OF TORQUES, TOUT : HP WILL BE CALCULATED

NOTE

- (1) TOUT NOT TABULATED IN ALLISON DATA
HENCE DETERMINED BY

$$1 : \text{REV} : T_{OUT} = T_{S2} \left(\frac{59}{56} \frac{132}{90} \right)$$

$$2 : T_K \left(\frac{132}{90} \right)$$

- (2) CALCS FOR 3RD NOT PERFORMED SINCE THERE IS AN ERROR
IN 3RD RANGE SPEEDS : PRESUMABLY IN TORQUE ALSO

- (3) 100% LEAK EFF ASSUMED

- (4) MAX "MOTOR" OUTPUT TORQUE OF 2437 IS FOR 100%
PUMP - MOTOR TORQUE EFFICIENCY

IN FACT BOTH TORQUE : VOLUMETRIC EFF ARE ASSUMED TO BE 100%
IN ALLISON TABLE SINCE PUMP HP = MOTOR HP
PUMP/MOTOR CIR = 35



FMC Corporation

▲ ABS SPD (IS ACTUALLY NEG.)

ENGINEERING SHEET

■ $T_{12} (\frac{52}{36} \frac{132}{90})$ SINCE TOUT NOT TAB.

Division: _____

Project: _____

Page 2 of _____

Title: XHM 650 TOUT: HP

▼ $T_k (\frac{132}{90})$

	OUTPUT			INPUT			"PUMP"			"MOTOR"		
	RPM	LGFT	HP	RPM	LGFT	HP	RPM	LGFT	HP	RPM	LGFT	HP
1	0	10.982	0	2600	0	0	1938	0	P 0	0	2437	M 0
	1 00	11.997	228	"	461	228	1774	619	209	451	2437	209
	2	13.220	503	"	1017	503	1610	1364	418	901	2437	418
	3	13.023	748	"	1510	748	1446	2026	558	1352	2168	558
	4	9.810	748	"	"	"	1282	"	495	1803	1442	495
	5	7.856	748	"	"	"	1119	"	432	2253	1806	432
	6	6.546	748	"	"	"	955	"	368	2704	715	368
2	7	5.606	747	"	"	"	1027	1796	M 351	2506	737	P 352
	8	4.905	747	"	"	"	1173	1319	295	2102	"	295
	9	4.360	747	"	"	"	1320	947	238	1699	"	238
	10 00	3.923	747	"	"	"	1467	650	182	1296	"	182
	11	3.567	747	"	"	"	1613	406	125	892	"	125
	12	3.271	747	"	"	"	1760	204	68.4	490	"	68.8
	13	3.018	747	"	"	"	1907	32	11.6	86	"	12.1
2	14	2.803	747	"	"	"	2053	115	P 45.0	-317	"	M 44.5
hi	15	2.617	747	"	"	"	2200	242	101	-721	"	101
	16	2.452	747	"	"	"	2347	354	158	-1124	"	158
3	17			"	"				M			P
	18			"	"							
	19			"	"							
	20 00			"	"							
	21			"	"							
	22			"	"							
3	23			"	"				P			M
	24			"	"							
	25			"	"							
	26			"	"							
	27			"	"							
	28			"	"							
	29			"	"							
	30 00			"	"							
	31			"	"							
	32			"	"							

Signature

Date of Signature

1 Aug 85

Initials

Date of Signature

Date Understood

Title: **XHM 650 Tout: HP**

	OUTPUT			INPUT			" PUMP "			" MOTOR "		
	RPM	LB FT	HP	RPM	LB FT	HP	RPM	LB FT	HP	RPM	LB FT	HP
↑	0	10,982	0	2600	0	0	-1938	0	P 0	0	2437	M 0
REV	-100	18127	193	"	389	193	-2102	523	209	-451	"	209
	-200	9397	358	"	721	357	-2266	968	418	-901	"	418
	-300	8762	500	"	1010	500	-2430	1356	627	-1352	"	627
	-400	8207	625	"	1263	625	-2593	1694	836	-1803	"	837
	-500	7720	735	"	1484	735	-2757	1991	1045	-2253	"	1045
↓	-600	6546	748	"	1510	748	-2921	2026	1127	-2704	2189	1127

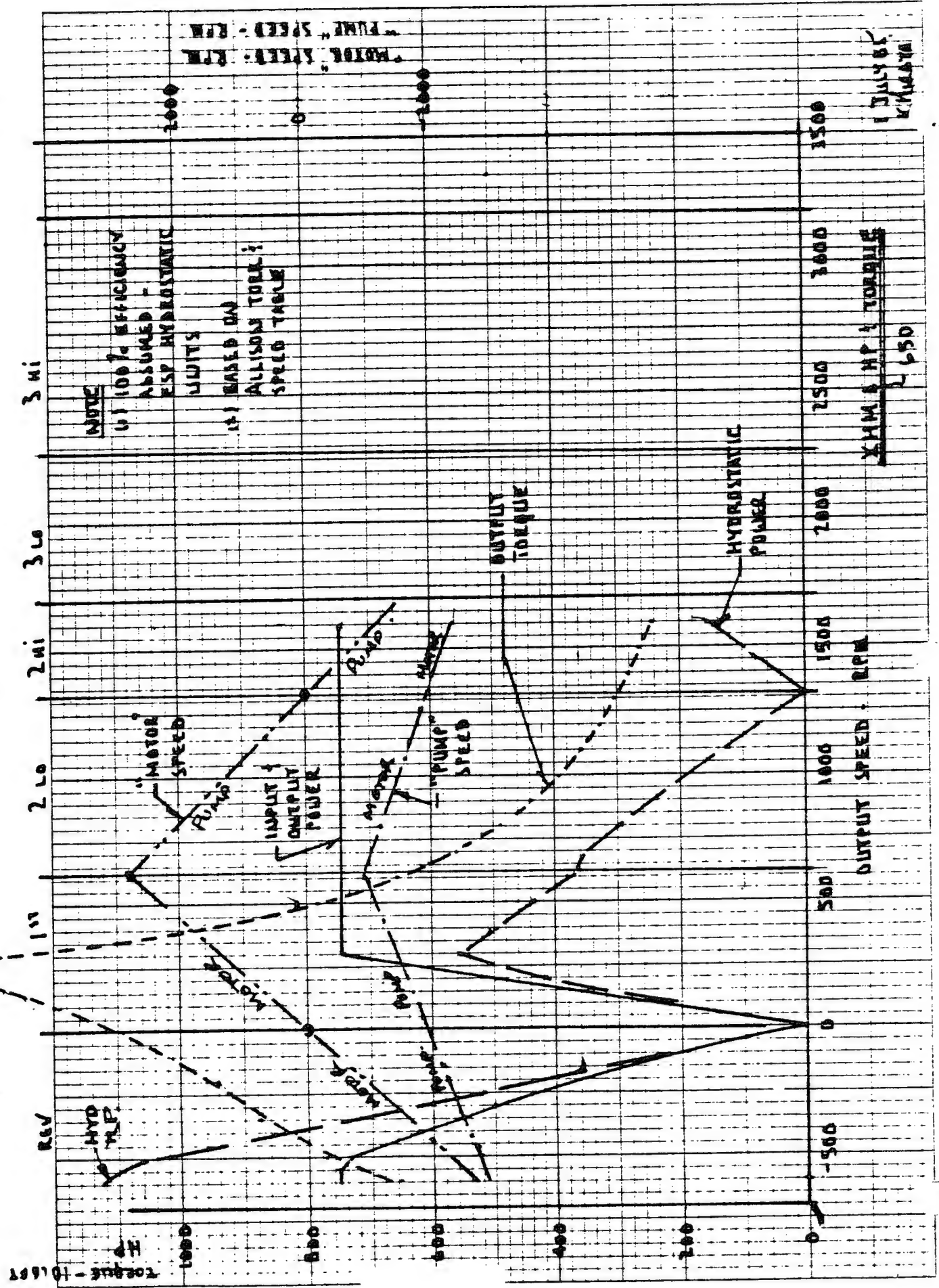
■ $T_{s2} \left(\frac{53}{56} \frac{132}{90} \right)$

Signature <u>KU</u>	Date of Signature <u>1 AUG 85</u>

D-6

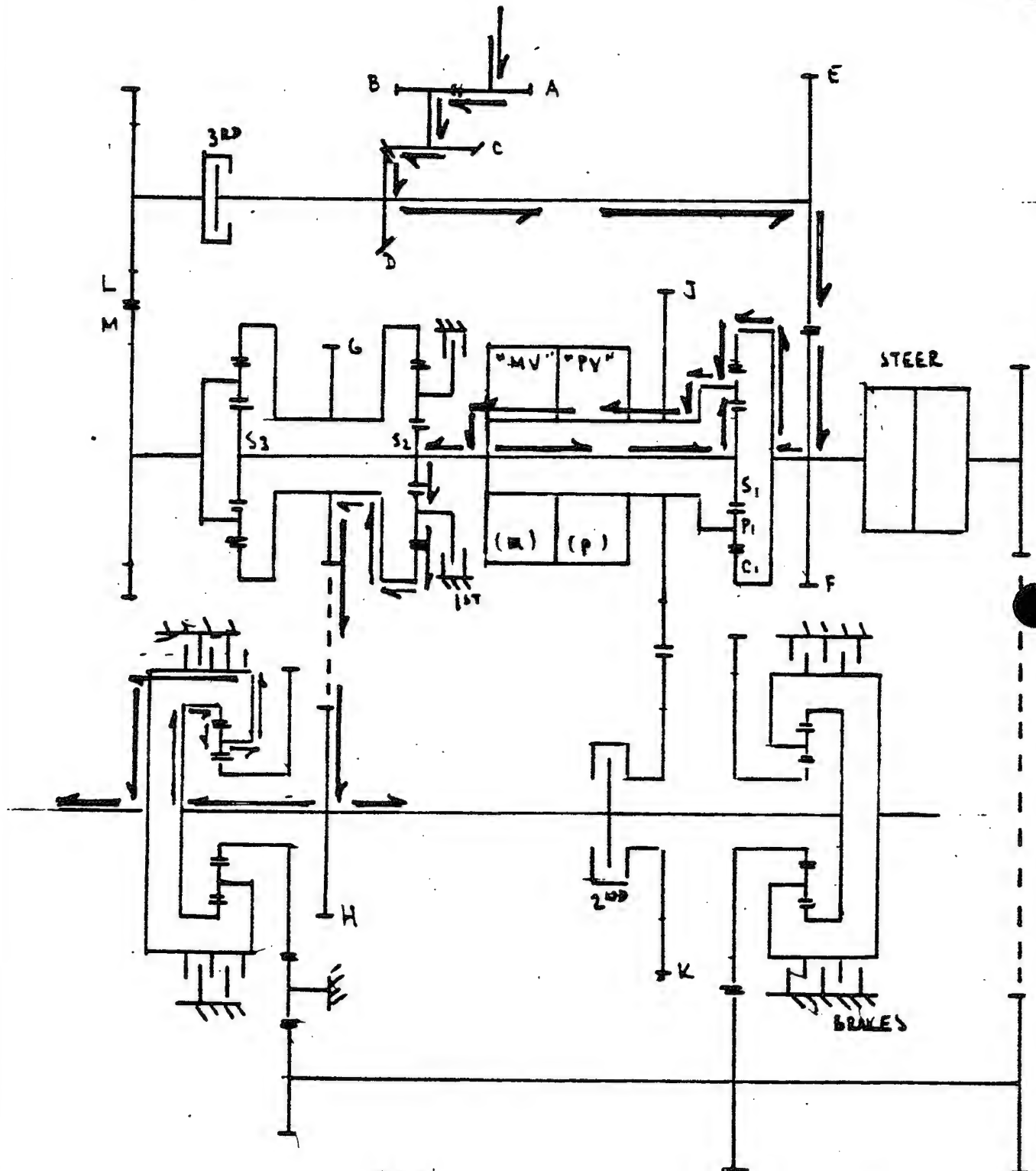
	Date of Signature	Date Understood

13220



Title: **XHM 650 POWER FLOW - SCHEMATIC**

Division: _____
 Project: _____
 Page ____ of ____



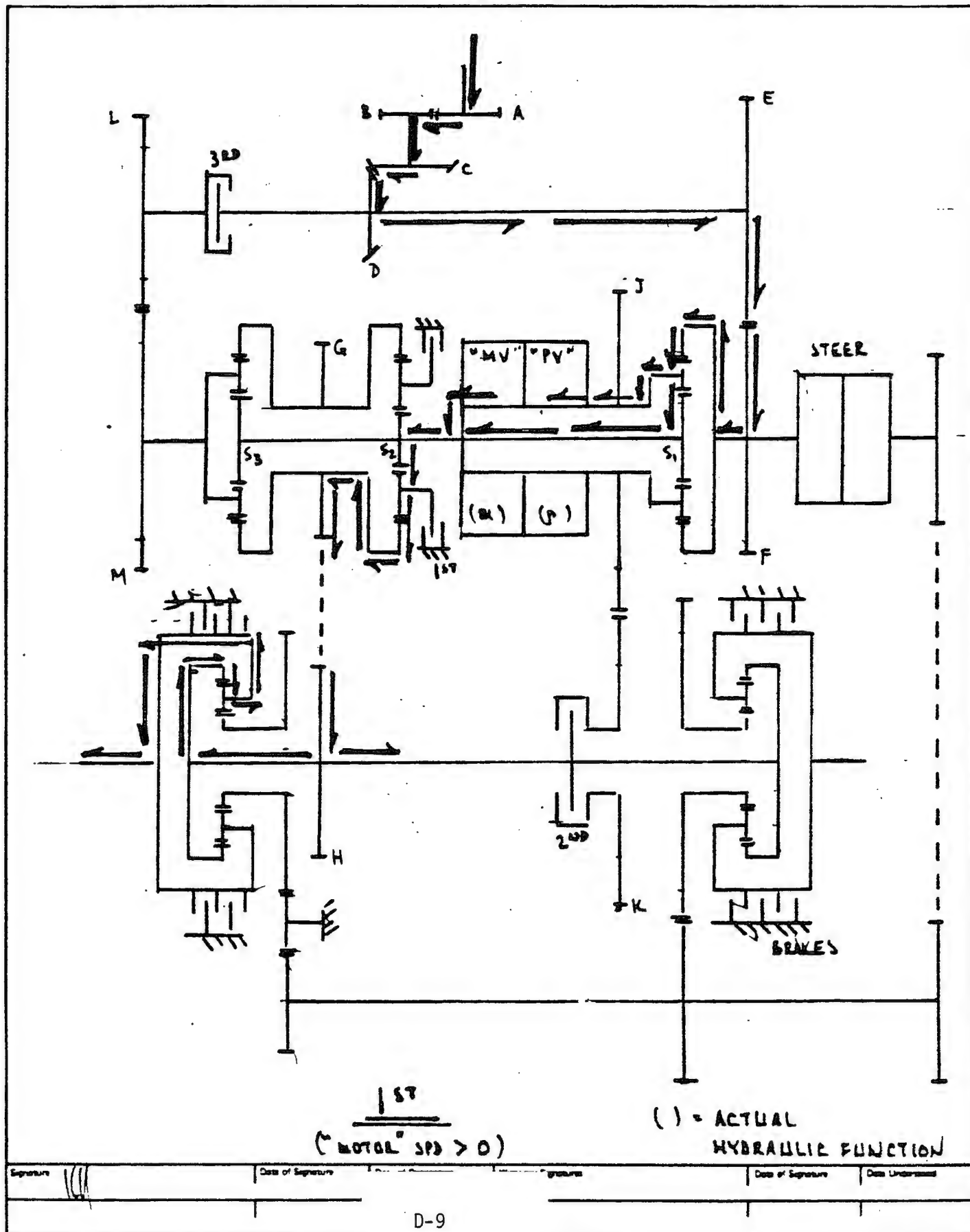
REV
 ("MOTOR" SPD < 0)

() = ACTUAL
 HYDRAULIC FUNCTION

Signature: [Signature] Date of Signature: 30 JULY 85 Doc: _____

Unit: _____ Date of Signature: _____ Date Understood: _____

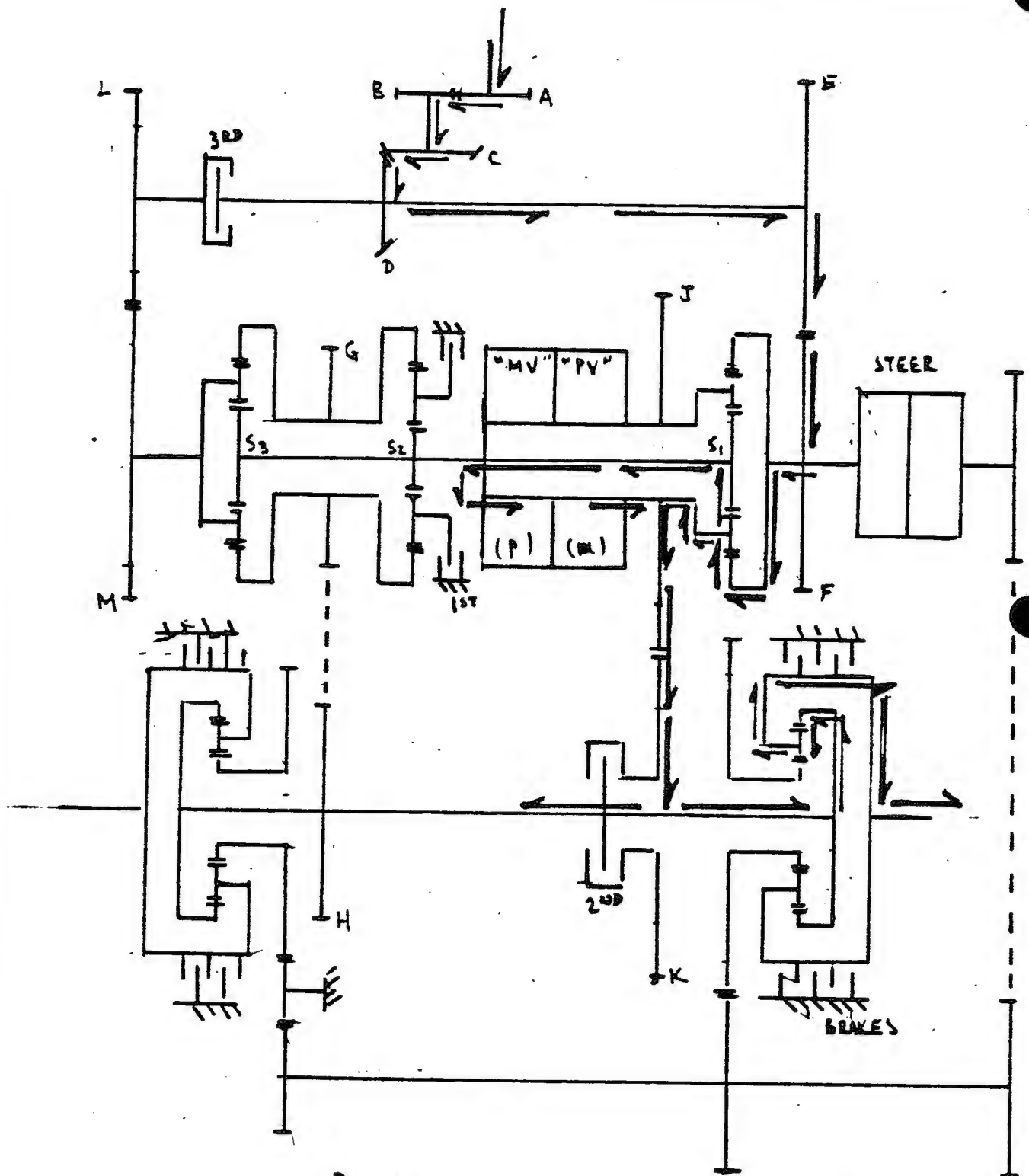
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Signature	Date of Signature	Signature	Date of Signature	Date Understood
<i>[Signature]</i>				

Title: **XHM 650 POWER FLOW — SCHEMATIC**

Division: _____
Project: _____
Page ____ of ____

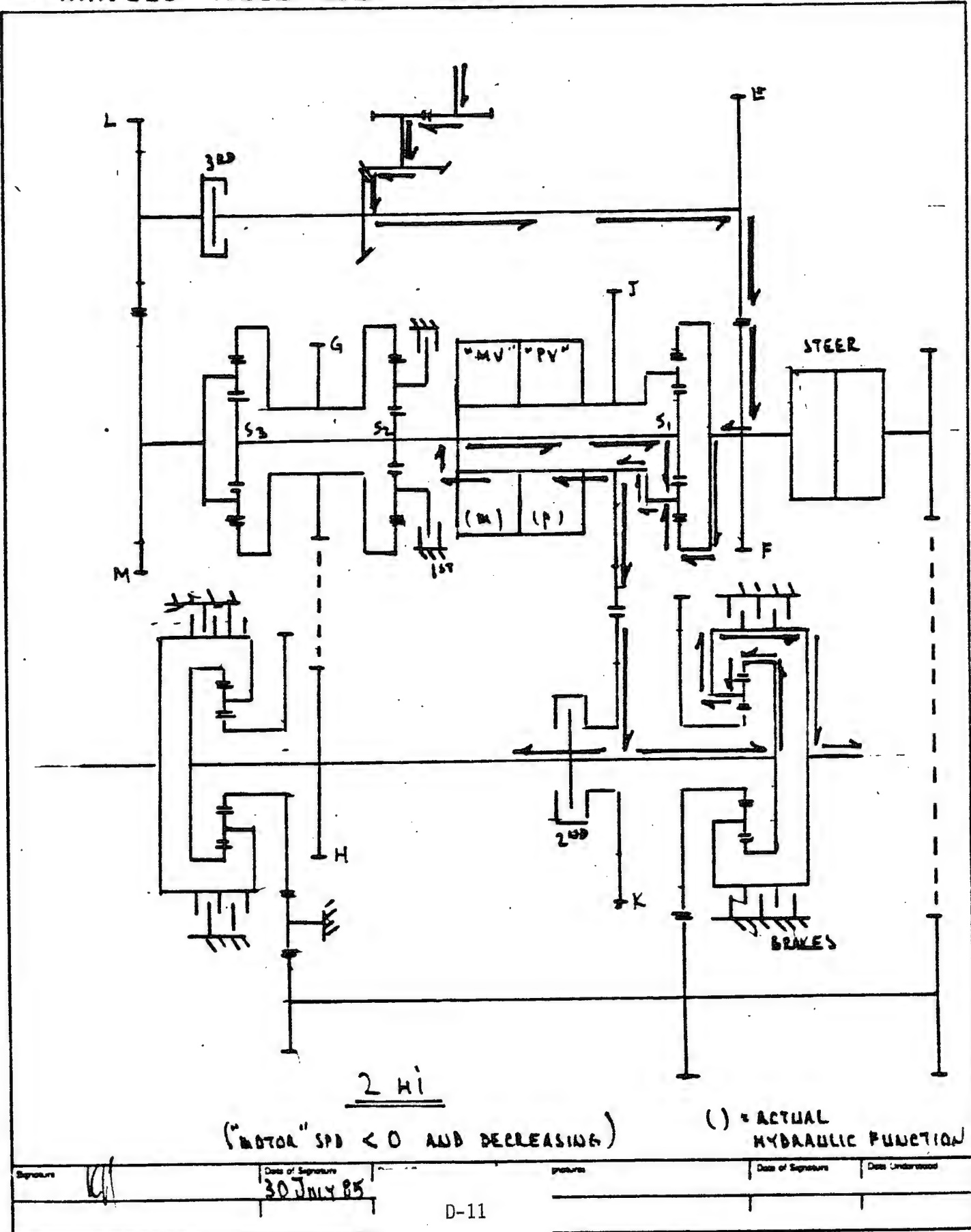


2 LO
("MOTBA" SPD > 0 BUT DECREASING)

() = ACTUAL
HYDRAULIC FUNCTION

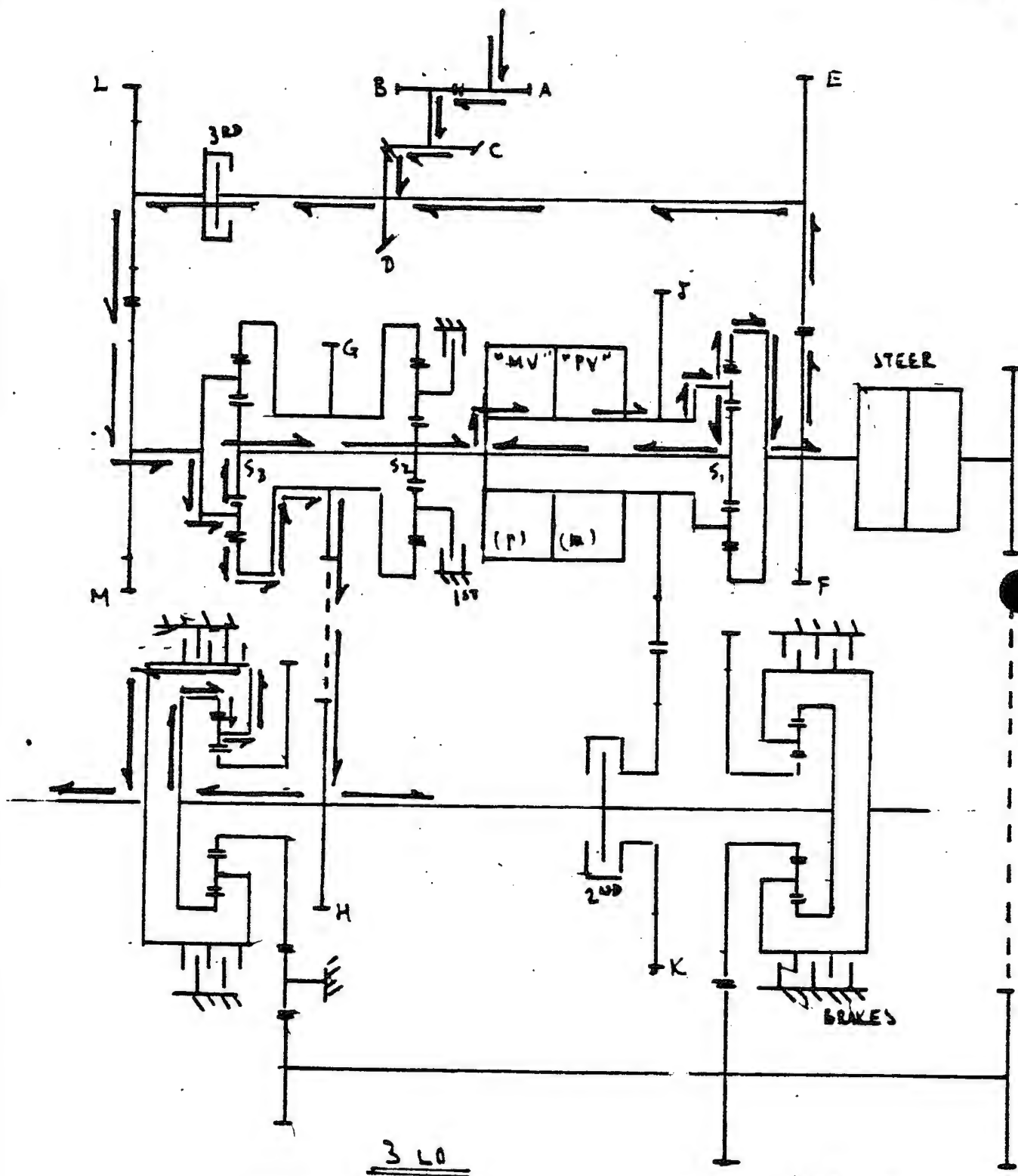
Signature	Date of Signature	Date of Correction	Witness Signature	Date of Signature	Date Understood
<i>[Signature]</i>	30 JULY 85				

Title: **XHM 650 POWER FLOW — SCHEMATIC**



Title: XHM 650 POWER FLOW - SCHEMATIC

Division: _____
 Project: _____
 Page ____ of ____

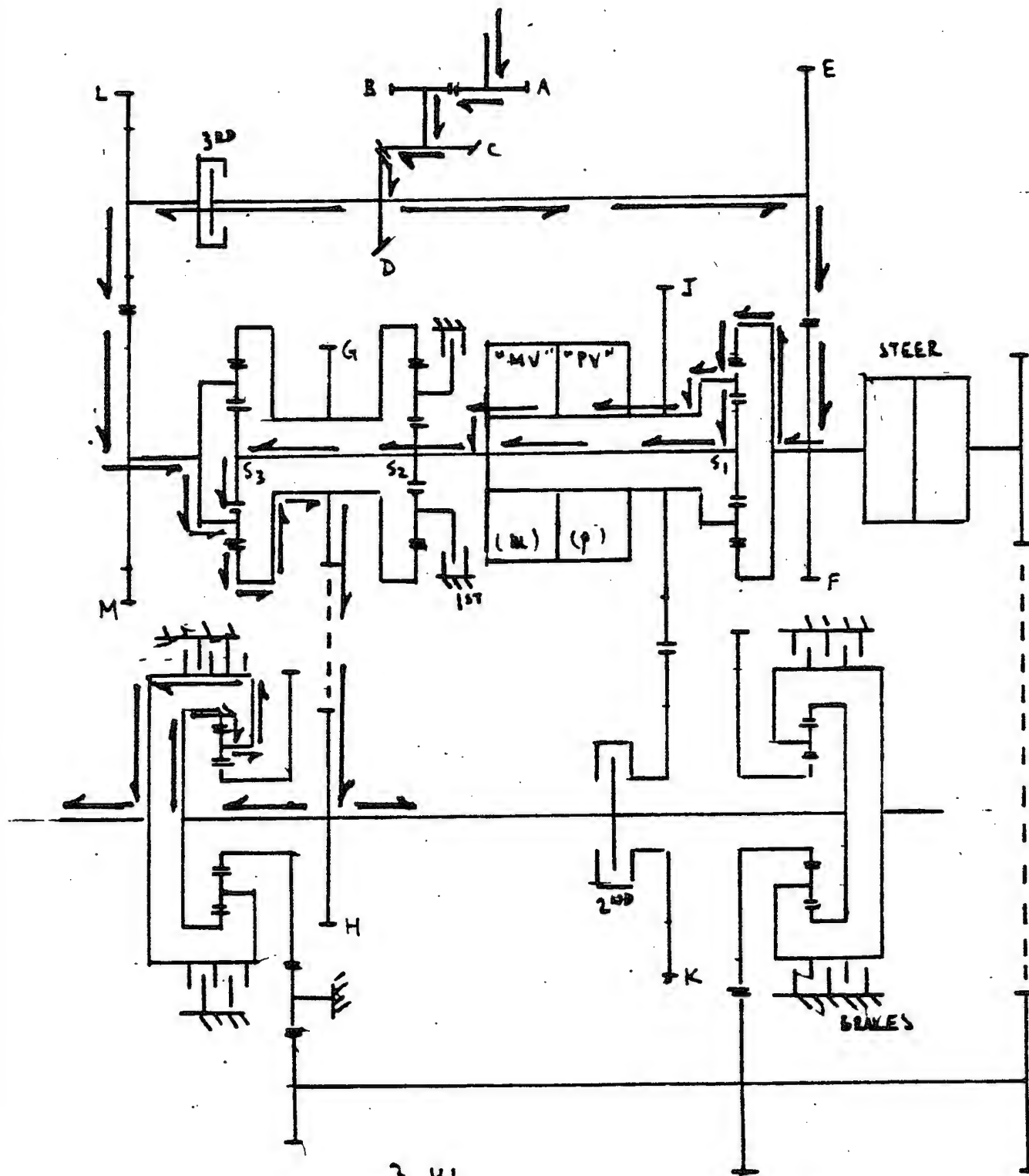


3 L0
 ("MOTOR" SPD < 0 BUT INCREASING)

() = ACTUAL
 HYDRAULIC FUNCTION

Signature <i>VCH</i>	Date of Signature 30 JULY 85	Date of Cancellation	Witness Signature	Date of Signature	Date Understood
D-12					

Title: XHM 650 POWER FLOW - SCHEMATIC



3 K1
("мотор" сраб > 0)

() = ACTUAL
HYDRAULIC FUNCTION

Signature	KV	Date of Signature	30 JULY 85

D-13

His Signatures	Date of Signature	Date Understood

Title: XHM 650 POWER FLOW

Division: _____
 Project: _____
 Page 2 of _____

	2 Hi (Wm < 0) INC			3 Lo (Wm < 0) INC			3 Hi (Wm > 0) INC		
	S _i	I _i	C _i	S _i	I _i	C _i	S _i	I _i	C _i
W	-	-	-	-	-	-	+	-	-
T	-	-	+	+	+	-	-	-	+
HP	(+)	+	(-)	(-)	(-)	+	(-)	(+)	-

	S _i	I _i	C _i	S _i	I _i	C _i	S _i	I _i	C _i
W							+	-	-
T				+	+	-	+	+	-
HP				(-)	-	(+)	(+)	-	(+)

CHECK (FOR 2600 RPM INPUT)

	2 Hi e 1600 RPM OUT			3 Lo e 2000 RPM OUT			3 Hi e 3200 RPM OUT		
	S _i	I _i	C _i	S _i	I _i	C _i	S _i	I _i	C _i
W	-1124.1	-3045.3	-2346.7	-722.4	-2045.3	-2200.6	2522.6	-3045.3	-1020.6
T	1.0	1.75	2.75	1.0	1.75	2.75	1.0	1.75	2.75
ITW	1124.1	5329.3	6453.3	722.4	5329.3	6051.7	2522.6	5329.3	2806.7

	S _i	I _i	C _i	S _i	I _i	C _i	S _i	I _i	C _i
W				-722.4	-3090.5	-2229.4	2522.6	-4344.8	-2229.4
T				1.0	1.75	2.75	1.0	1.75	2.75
ITW				722.4	5408.3	6130.9	2522.6	8653.3	6130.9

"PUMP" ACTS AS MOTOR, "PUMP" ACTS AS PUMP

Title: XHM 650 POWER FLOW

Division: _____

Project: _____

Page 1 of 2

GROUND RULES
 INPUT HP = + OUTPUT HP = -
 S & I HAVE SAME SIGN FOR TORQUE C WILL HAVE OPPOSITE SIGN

(1) SENSE OF HP DERIVED FROM GROUND RULE

REV	1 ST (W _M > 0; INC)			2 ND (W _M > 0; DEC)		
	S _i	I _i	C _i	S _i	I _i	C _i
W	-	-	-	+	-	-
T	-	-	+	-	-	+
HP	(+)	+	(-)	(-)	+	(-)

CHECK (FOR 2600 RPM INPUT)

REV	- 608 RPM OUT			1 ST - 200 RPM OUT			2 ND LO - 1200 RPM OUT		
	S _i	I _i	C _i	S _i	I _i	C _i	S _i	I _i	C _i
W	-2740.2	-3045.3	-2934.4	901.4	-3045.3	-1610.1	489.3	-3045.3	-1760.6
T	1.0	1.75	2.75	1.0	1.75	2.75	1.0	1.75	2.75
TW	2740.2	5329.3	8069.6	901.4	5329.3	4427.8	489.3	5329.3	4840.0

▼ ASSUMED

Signature: <u>KA</u>	Date of Signature: <u>29 JULY 85</u>	Da: _____	res: _____	Date of Signature: _____	Date Understood: _____
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HMFT 500
SPEED ANALYSIS

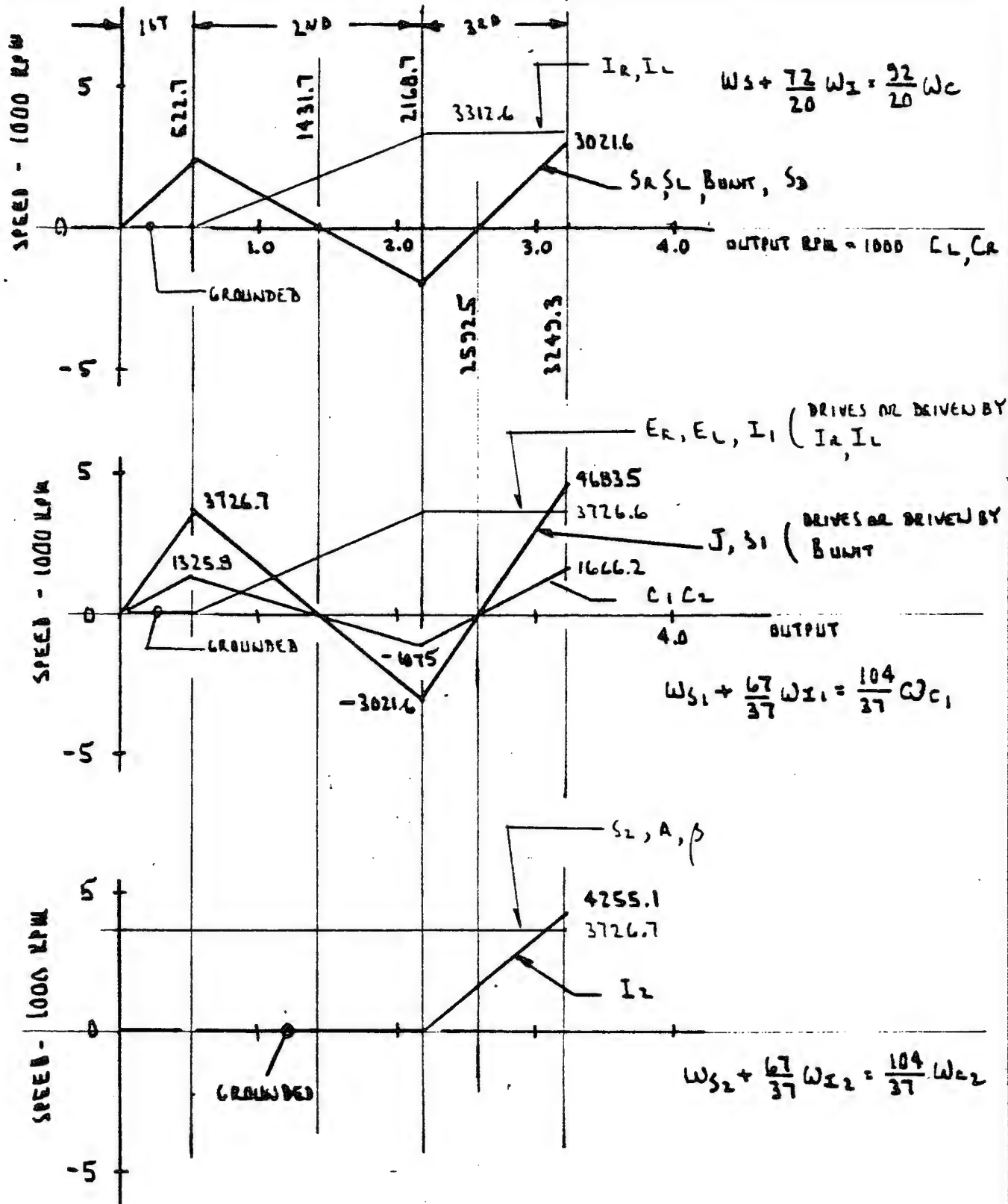


Title: LE HAPT 500 SPEED ANALYSIS

Division: _____

Project: _____

Page ____ of ____



Signature

Date of Signature

Signature

Date of Signature

Date Understood

Title: GE HMPT 500 SPD ANALYSIS

Division: _____
Project: _____
Page ____ of ____

W = ENGINE SPD = 2600 RPM CONSTANT

1st 2nd 3rd

INPUT

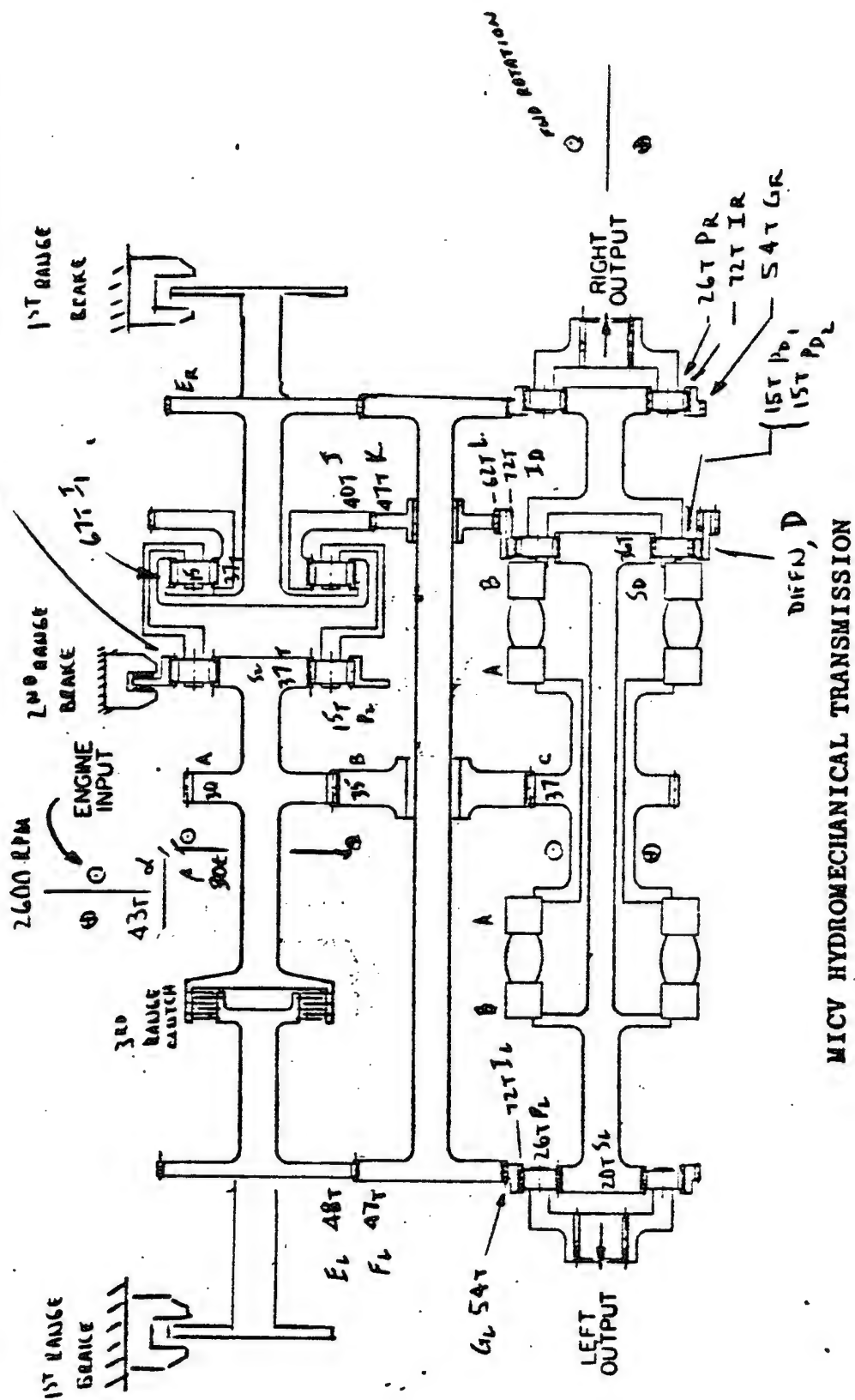
OUT

α	2600	2600	2600	2600	2600	2600
P + A	3726.7	3726.7	3726.7	3726.7	3726.7	3726.7
B	-3194.3	-3194.3	-3194.3	-3194.3	-3194.3	-3194.3
C (AUMT)	3021.6	3021.6	3021.6	3021.6	3021.6	3021.6
B _L : B _R	0	2404.3	0	-1949.4	0	3021.6
S _L S _R						
C _L C _R	0	522.7	1431.7	2168.7	2592.5	3249.3
I _L I _R	0	0	1829.3	3312.6	3312.6	3312.6
C _D	0	2404.3	0	-1949.4	0	3021.6
I _D , L	"	"	"	"	"	"
S _D , S _L	"	"	"	"	"	"
L, I _D	"	"	"	"	"	"
K	0	-1581.5	0	1285.8	0	-1993.0
J, S ₁	0	3726.7	0	-3021.6	0	4683.5
I ₁	0	0	2058.0	3726.6	3726.7	3726.7
S ₁ , J	0	3726.7	0	-3021.6	0	4683.5
C ₁	0	1325.8	0	-1075.0	0	1666.2
C ₂	"	"	"	"	"	"
I ₂	0	0	0	0	1668.7	4255.1
S ₂ , A, P	3726.7	3726.7	3726.7	3726.7	3726.7	3726.7
E _R E _L	0	0	2058.0	3726.6	3726.7	3726.7
F _R F _L	0	0	-2101.8	-3805.9	-3806.0	-3806.0
G _R G _L	0	0	1829.3	3312.6	3312.6	3312.6

Signature _____ Date of Signature _____

Signature _____ Date of Signature _____ Date Understood _____

LEFT SIDE, L.

RIGHT SIDE, R

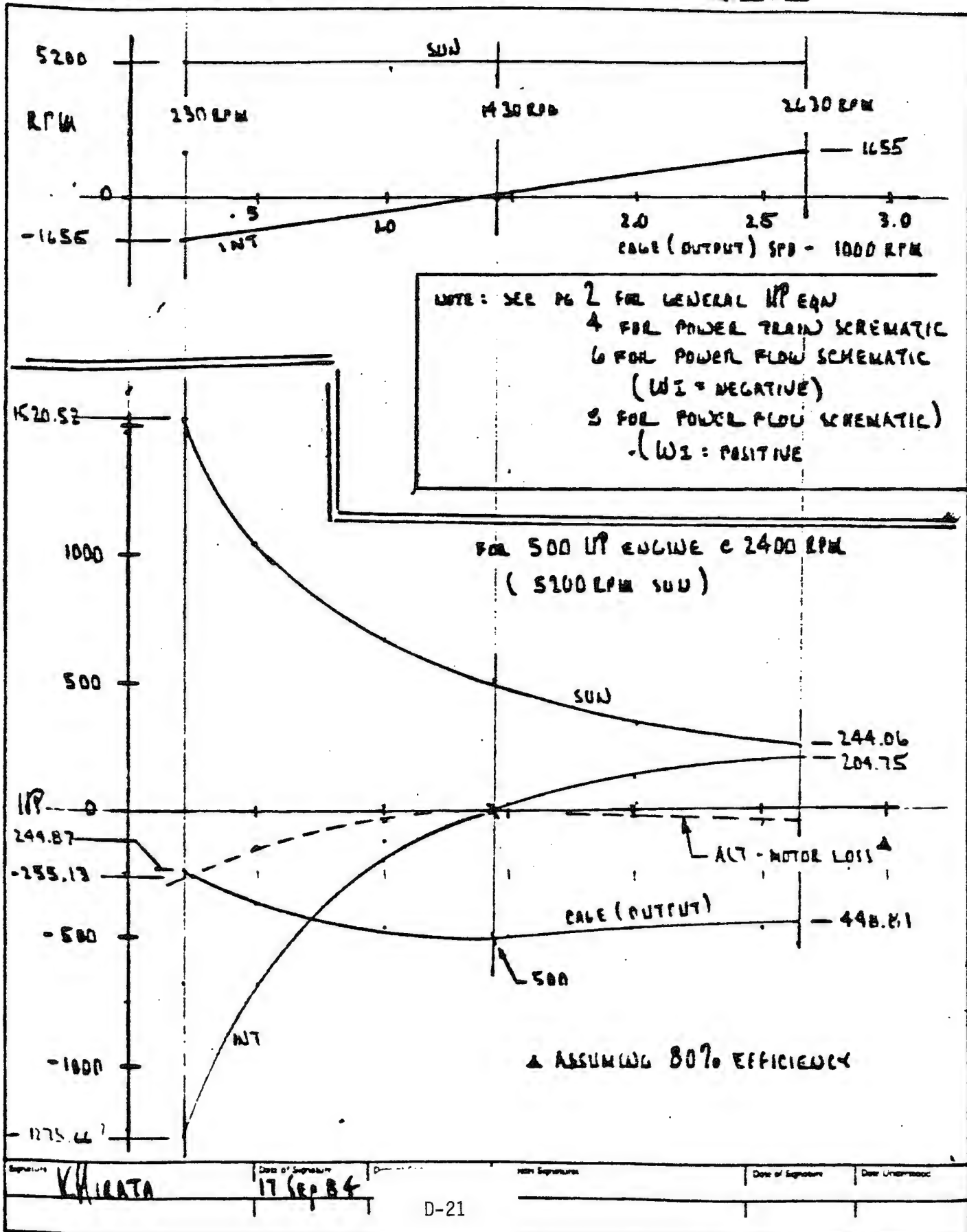
MICV HYDROMECHANICAL TRANSMISSION

21 CIR HYDRAULIC PUMP/MOTORS

6E HMPT 500 SPD ANALYSIS PL 3 AF 3

TYPICAL SPLIT
POWER FLOW RANGE
SECTION ANALYSIS

Title: 117 ANALYSIS - SPLIT POWER FLOW RANGE SECTION



Signature: V. HIRATA

Date of Signature: 17 SEP 84

Title: IP ANALYSIS - SPLIT POWER FLOW RANGE SECTION

Division: _____
Project: _____
Page 2 of _____

SUMMARY OF IP EQNS

FOR ENGINE IP = 500

ALT - MOTOR EFF = 80%

$$m = \frac{W_1}{W_2} = 2.636$$

CASE I W₂ = NEGATIVE

$$T_s = \frac{500(5252)}{.8m W_2 + W_1} \quad \text{LB FT}$$

$$HP_s = \frac{500(5252)}{.8m W_2 + W_1} \cdot \frac{W_1}{5252} = 500 \frac{W_1}{.8m W_2 + W_1}$$

$$HP_z = \frac{500(5252)}{.8m W_2 + W_1} \cdot \frac{W_2}{5252} = 500 \frac{m W_2}{.8m W_2 + W_1}$$

$$HP_c = HP_{out} = \frac{500(5252)}{.8m W_2 + W_1} \cdot \frac{W_1 + m W_2}{5252} = 500 \frac{W_1 + m W_2}{.8m W_2 + W_1}$$

$$HP_{loss} = .2 HP_z = 100 \frac{m W_2}{.8m W_2 + W_1}$$

CASE II W₂ = POSITIVE

$$T_s = \frac{500(5252)}{1.25m W_2 + W_1} \quad \text{LB FT}$$

$$HP_s = \frac{500(5252)}{1.25m W_2 + W_1} \cdot \frac{W_1}{5252} = 500 \frac{W_1}{1.25m W_2 + W_1}$$

$$HP_z = \frac{500(5252)}{1.25m W_2 + W_1} \cdot \frac{m W_2}{5252} = 500 \frac{m W_2}{1.25m W_2 + W_1}$$

$$HP_c = \frac{500(5252)}{1.25m W_2 + W_1} \cdot \frac{W_1 + m W_2}{5252} = 500 \frac{W_1 + m W_2}{1.25m W_2 + W_1}$$

$$IP_{ALT} = \frac{IP_z}{.8}$$

$$IP_{LOSS} = .2 IP_{ALT} = .25 IP_z$$

Title: IP ANALYSIS - SPLIT POWER FLOW RANGE SECTION

CASE I - CONT

 FOR $W_s = 5200$

 CALCULATE IP & $W_c = 500 \ 1000 \ 1430$

W_c	500	1000	1430	230.3
W_z	-1283.00	-593.32	0	-1655
IP_s	1042.33	658.43	500	1520.52
IP_z	-677.92	-198.03	0	-1275.66
IP_c	-364.42	-460.39	-500	-244.87
IP_{LOH}	-135.58	-39.61	-0	-255.13

 2.1772

CASE II - CONT

 CALCULATE IP & $W_c = 1500 \ 2000 \ 2500$

W_c	1500	2000	2500	2630
W_z	96.36	786.04	1475.72	1655
IP_s	471.23	333.76	258.39	244.06
IP_z	23.02	132.99	193.29	204.75
IP_c	-494.25	-466.75	-451.68	-448.81
IP_{LOH}	-5.75	-33.25	-48.32	-51.19

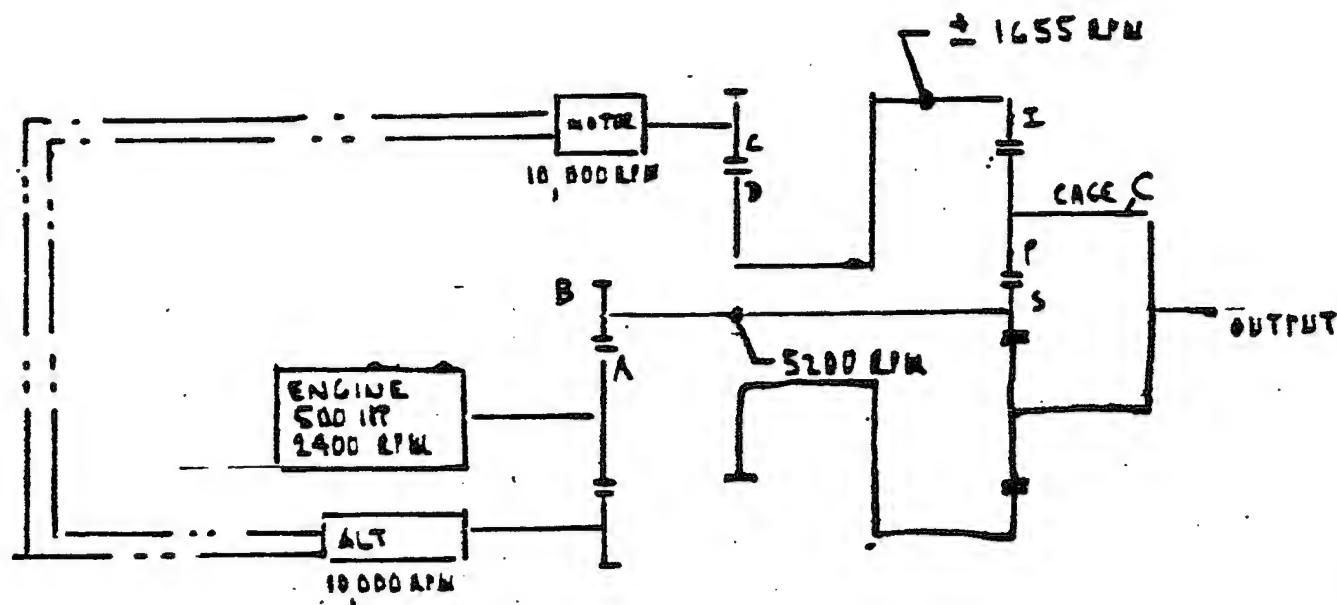
 2.5172

 Signature 1/1 Date of Signature 17 Sep 84

 Date of Signature _____
 Date of Signature _____

TITLE: **KP ANALYSIS - SPLIT POWER FLOW RANGE SECTION**

Division: _____
Project: _____
Page 4 of _____



$$\frac{N_B}{N_A} = \frac{1}{2.1667}$$

$$\frac{N_B}{N_C} = 6.0423$$

$$\frac{N_I}{N_S} = 2.636 \approx M$$

PROPOSED SPD CHANGE SECTION

OUTPUT SPEED, ω_C

$$\omega_C = \frac{\omega_S + M \omega_I}{1 + M} = \frac{\omega_S + 2.636 \omega_I}{3.636}$$

e $\omega_S = 5200$, $\omega_I = -1655$

$$\omega_C = \frac{5200 + 2.636(-1655)}{3.636} = \underline{\underline{230.3 \text{ RPM}}}$$

ω_C
(e ω_I
= -1655)

e $\omega_S = 5200$, $\omega_I = 0$

$$\omega_C = \underline{\underline{1430.1 \text{ RPM}}}$$

ω_C
(e ω_I
= 0)

e $\omega_S = 5200$, $\omega_I = 1655$

$$\omega_C = \underline{\underline{2630.0 \text{ RPM}}}$$

ω_C
(e ω_I
= 1655)

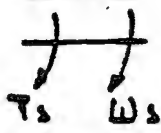
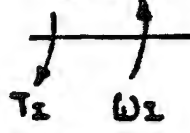
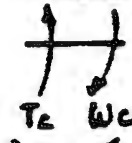
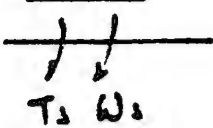
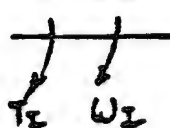
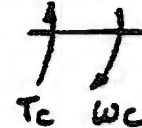
Signature: [Signature] Date of Signature: 17 SEP 04 Date Understood: _____

Title: IPP ANALYSIS - SPLIT POWER FLOW RANGE SECTIONGROWN RULES FOR ANALYSIS OF IPP : TORK

INPUT IPP = + SIGN

OUTPUT IPP = - SIGN

SUN & INT TORK ARE SAME SENSE

CASE I $\omega_2 = -$ E SUN+ IPP
(INPUT)E INT- IPP
(IE OUTPUT)E CAGE- IPP
(IE OUTPUT)CASE II $\omega_2 = +$ E SUN+ IPP
(INPUT)E INT+ IPP
(INPUT)E CAGE- IPP
(OUTPUT)IPP ANALYSIS - CASE I ($\omega_2 = \omega_{REL}$)

SINCE IPP IS OUTPUT IPP, THE SO CALLED MOTOR BECOMES AN ALT AND RECIRCULATES IPP BASIC INTO THE SUN.

ASSUME 80% OVERALL EFF FOR THE ALT-MOTOR EFF.

ALT-MOTOR EFF

Signature

Date of Signature

14 SEP 84

Date

Date

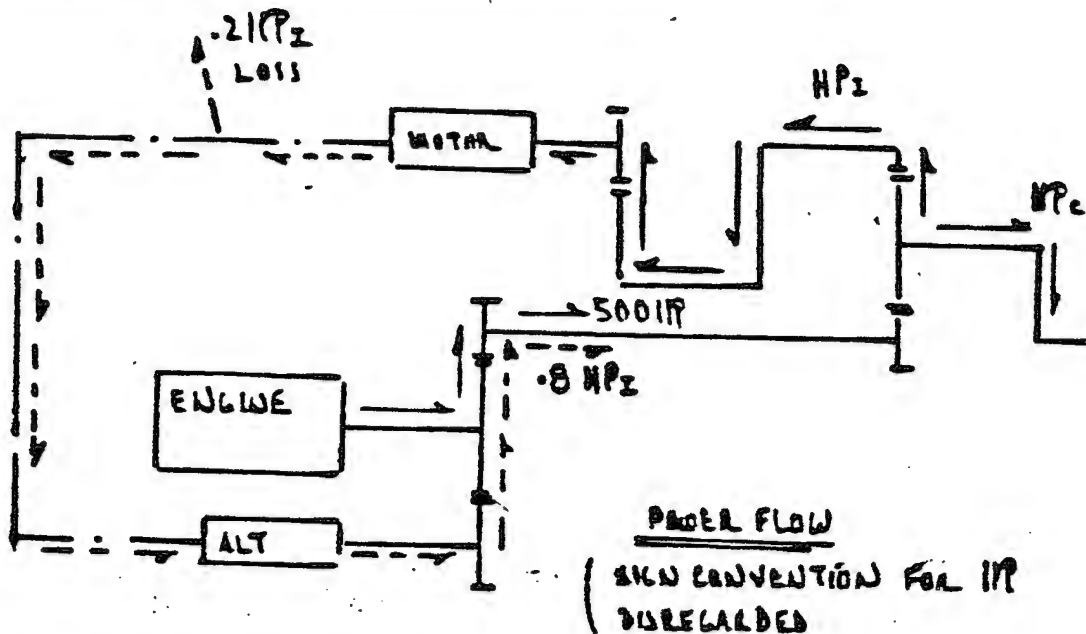
Date of Signature

Date Understood

Title: IP ANALYSIS - SPLIT POWER FLOW RANGE SECTION

Division: _____
Project: _____
Page 6 of _____

CASE I - IP ANALYSIS $W_I = NEG$



FOR THE OVERALL SYSTEM

$$500 + .21 IP_2 + IP_c = 0 \quad (a)$$

NOTE IP_2 & IP_c ARE NEG.

FOR $W = RPM$ $T = LGFT$

$$\left. \begin{array}{l} T_I = m T_s \\ W_I = W_s \end{array} \right\} IP_I = \frac{m T_s W_I}{5252} \quad (b)$$

$$\left. \begin{array}{l} T_c = -(1+m) T_s \\ W_c = \frac{W_s + m W_I}{1+m} \end{array} \right\} IP_c = - \frac{T_s (W_s + m W_I)}{5252} \quad (c)$$

NOTE: CASE TORK IS OPPOSITE TO SUN & INT
SUBSTITUTING (b) & (c) INTO (a)

$$500 + \frac{.21 m T_s W_I}{5252} - \frac{T_s (W_s + m W_I)}{5252} = 0$$

Signature: [Signature] Date of Signature: 10 Sep 84

Date of Signature: _____ Date Understood: _____

Title: IPP ANALYSIS - SPLIT POWER FLOW RANGE SECTION

$$500 + \frac{T_s}{5252} [.2 W_2 - W_3 - W_4] = 0$$

$$T_s = \frac{500 (5252)}{.8 W_2 + W_3}$$

CASE I

GENERAL
T_s
EQN

For $W_3 = 5200$ $W_2 = -1655$ $W_4 = 2636$

$T_s = 1535.73$ LB FT

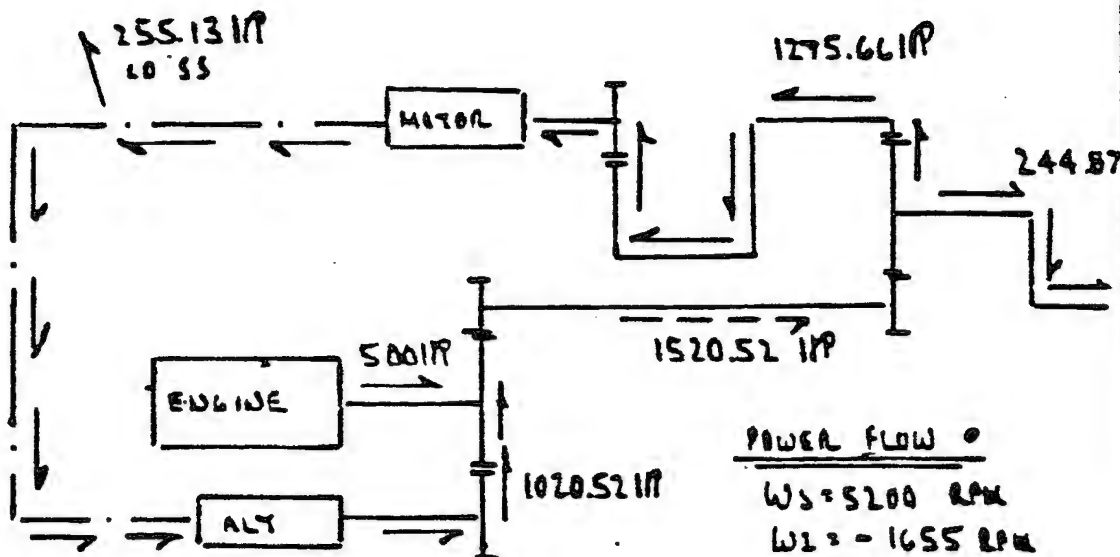
\therefore $MP_6 = 1520.52$

$MP_2 = -1275.66$

$.8 MP_2 = 1020.52$

$.2 MP_2 = -255.13$

$MP_c = -244.87$



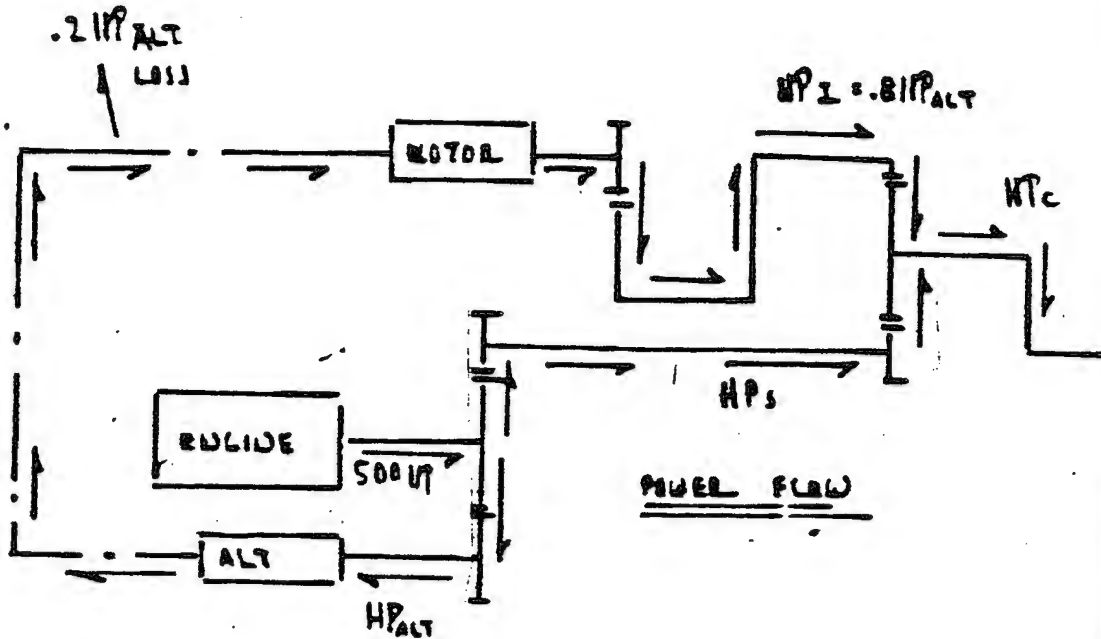
Signature: [Signature] Date of Signature: 17 Sep 84 Date: _____

Signature: _____ Date of Signature: _____ Date Understood: _____

Title: 1P ANALYSIS - SPLIT POWER FLOW RANGE SECTION

Division: _____
Project: _____
Page 8 of _____

CASE II 1P ANALYSIS $W_1 = \text{POSITIVE}$



$$500 - .21P_{ALT} + W_{Pe} = 0$$

$$\text{or } 500 - .25W_1 + W_{Pe} = 0 \quad (a)$$

$$\text{But } W_{PI} = \frac{W_1 T_s}{5252} \quad (b)$$

$$W_{Pe} = -\frac{T_s (W_1 + W_2)}{5252} \quad (c)$$

SUBSTITUTING (b) & (c) INTO (a)

$$500 - \frac{.25 W_1 T_s}{5252} - \frac{T_s (W_1 + W_2)}{5252} = 0$$

$$500 - \frac{T_s}{5252} [-.25 W_1 - W_1 - W_2] = 0$$

$$T_s = \frac{500 (5252)}{1.25 W_1 + W_2}$$

GENERAL
 T_s
EQN

Signature: [Signature] Date of Signature: 17 Sep 84 Day: _____

Date of Signature: _____ Date Understood: _____

Title: **HP ANALYSIS - SPLIT POWER FLOW RANGE SECTION**

Division: _____

Project: _____

Page **4** of **7**

CASE II CONT

From $W_1 = 5200$; $W_2 = 1655$

$T_S = 246.50$ lbf

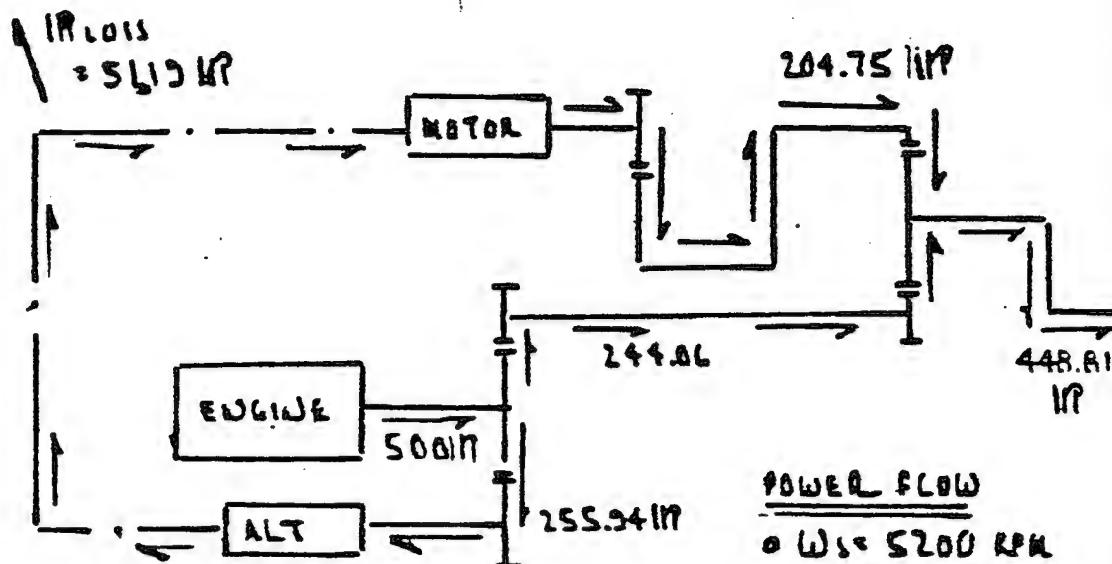
$\therefore IP_1 = 244.06$

$IP_2 = 204.75$

$IP_{ALT} = 255.34$

$IP_C = -448.81$

$.2 IP_{ALT} = 51.19 \approx IP_{LOSS}$



POWER FLOW

$W_1 = 5200$ RPM

$W_2 = 1655$ RPM

Signature: [Signature] Date of Signature: 17 Feb 84 Date of: _____

Date of Signature: _____ Date Understood: _____

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APPENDIX E

ELECTRIC VEHICLE PERFORMANCE SIMULATION

Appendix E Electric Vehicle Performance Simulation

E.1 Major Program Capabilities

Electrically driven, tracked vehicle-performance is simulated by this software package. Parameters which may be investigated include detailed electrical system performance, vehicle track dynamics, system losses and efficiency, incremental and average gross vehicle dynamics, and fuel economy. There are four subprograms which have been created to specifically consider each of these areas in detail. A brief description of each is given below.

E.1.1 Constituent Subprograms

- o Electric Drive Performance - Steady-state vehicle powertrain analysis with detailed emphasis on electric power drive parameters. Electric motor voltages, currents, generated power and alternator/generator output are calculated, along with energy usage, heat rejection, and fuel use impact.

- o Vehicle Acceleration Performance - Analysis of dynamic vehicle performance which realistically simulates the gross vehicle mission over the terrain conditions. Acceleration, deceleration, braking, and constant velocity conditions are considered.

- o Acceleration Dynamics Routine - Detailed analysis of full power acceleration during turning and nonturning maneuvers on user defined grades and surfaces. Incremental dynamic parameters are generated and tabulated.

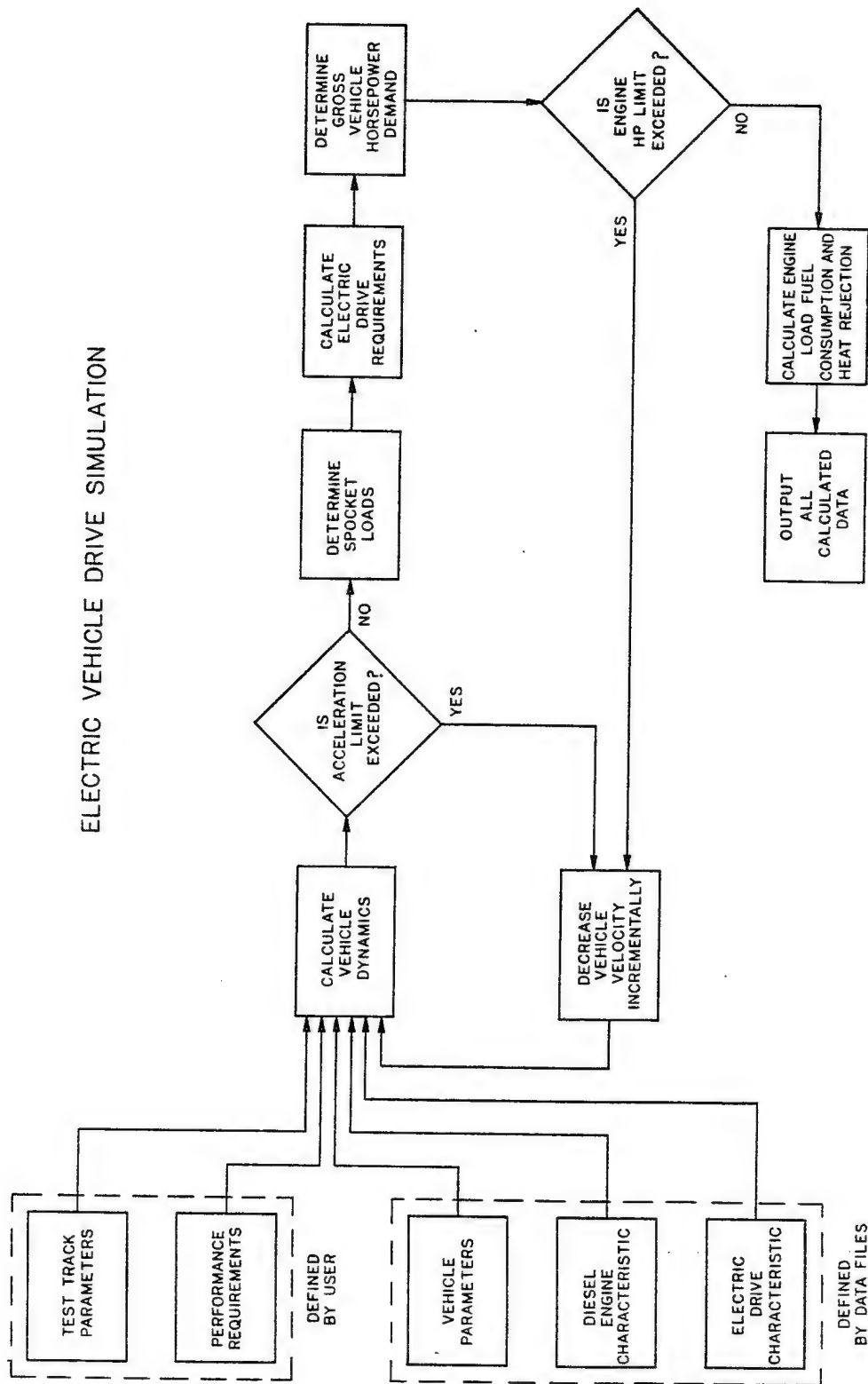
- o Reduction Dynamics Routine - Detailed analysis of speed/torque loading of all vehicle power train reduction elements. Final sprocket drives and prime mover interface reductions are included in the analysis.

Of four subprograms provided, the first two are perhaps the most useful for the consideration of the vehicle electric drive and the impact that it has on the overall vehicle mission. The latter two routines are best utilized for detailed investigation of those processes which help to make up the overall mission, but are not the parameters of major interest from a mission viewpoint. For this reason all further discussion will focus on the performance subprograms.

E.1.2 Performance Model Description

Each of the performance subprograms outlined above rely on an iterative energy balance technique to yield each steady-state operating point of the vehicle. The basic algorithm for this strategy is shown in Figure E.1.2-1. Test track parameters and

ELECTRIC VEHICLE DRIVE SIMULATION



performance requirements are defined and input by the user, along with vehicle, engine, and electric drive data which are resident within the program's data files. The vehicle dynamics are then calculated utilizing a Merritt's track model which considers the track dynamics based on empirical data. A centrifugal acceleration calculation is then performed to determine if any set acceleration limit is exceeded, such as personnel restrictions or vehicle track slip (surface coefficient or friction). If exceeded, the vehicle velocity is reduced and the process iterates until the acceleration falls within the selected bounds. The sprocket loads which have been calculated are used to determine what the electrical requirements are for each of the sprocket motors. This data is reflected back through the electrical system, ultimately to the prime mover, where the gross vehicle horsepower demand is calculated. At this point the energy balance is tested. If the fixed maximum output power of the prime mover is adequate for the present demand, the resultant system heat rejection and fuel consumption are calculated. If the system demands exceed the capabilities of the engine, the vehicle load is reduced by lowering the velocity until an energy balance is achieved. When this has been accomplished, either the calculated data is output to the user, as in the Electric Drive Performance subprogram, or it is further utilized in an acceleration or deceleration routine as in the Vehicle Acceleration Performance subprogram.

E.2 Program Options Available

The following six basic categories represent the various options which are available to the user from the program data files. Certain of the parameters must be defined by the user, such as the performance limitations which are addressed below.

E.2.1 Test Courses

There are four resident test courses provided within the software package. Each is broken down into segments of defined length, grade, and turn radius.

- o MERADCOM Test Course - This course consists of a well defined track which is located in the Aberdeen Proving Ground, Maryland. Sixteen segments make up the track, which has a total circumference of 2.5 miles.

- o Speed on Slope - A track consisting of thirteen segments of arbitrary length (1000 ft) was fabricated to aid in the derivation of the contractually required speed on slope curve. Grades from +60 percent to -60 percent are provided with intermediate grade points selected every 5 percent.

- o Tractive Effort vs. Speed - This test track is set up with grade values which yield a relatively uniform distribution of tractive effort values (TE) when plotted against speed.

o Churchville Test Course - This test course is the most rigorous and complex provided in the software package. Highly detailed topographical maps of the Churchville area (part of Aberdeen Proving Grounds) were used extensively in the definition of this track, which is comprised of 88 segments. Steep grades, sharp curves, and short segments serve to make this a very demanding and useful evaluator of vehicle performance. The course, which is 3.33 miles in length, is shown in topographic form in figure E.2.1-1, and in elevation in Figure E.2.1-2.

E.2.2 Course Surface

To provide greater flexibility in the number of options available to the user, the surface coefficient of friction (μ) is selected apart from the physical dimensions of each course. Those available are given below:

- o Concrete/Asphalt, μ = 0.80 (MERADCOM)
- o Compacted Soil, μ = 0.70 (Churchville)
- o Loose Sand, μ = 0.55
- o Rocky Terrain, μ = 0.45
- o User Defined

E.2.2 Vehicle/Engine

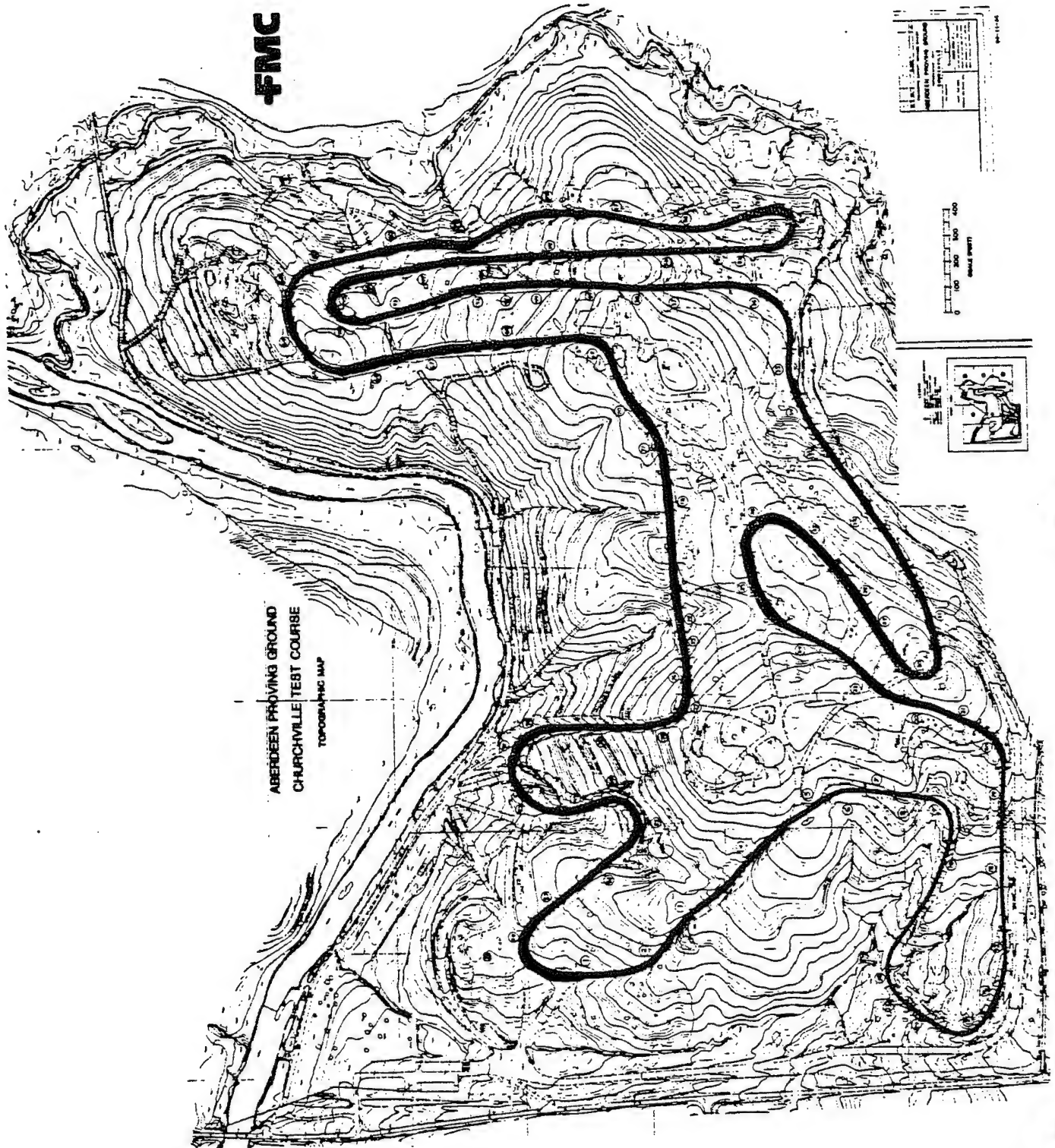
Both the 19.5 and 40.0 ton TACOM specified tracked vehicles are resident within the software package, as well as the specified engines (Cummins VTA-903 for the 19.5 ton, and the AD-1000 for the 40.0 ton). The option is also given to the user to define the parameters of their own tracked vehicle.

E.2.4 Engine Scheduling

Both constant and variable diesel engine scheduling is available to the user to aid the determination of which is more fuel efficient. Each technique utilizes fuel consumption curves for the VTA-903, and the AD-1000. With constant scheduling, fuel consumption is based on a relationship which is only dependent on demanded HP, whereas with variable scheduling, the demanded HP defines the engine speed which then yields the appropriate fuel consumption.

E.2.5 Electric Drive Type

There are eight electric drive types which are resident within the software package. The entire electric propulsion system is



FMC

ABERDEEN PROVING GROUND
CHURCHVILLE TEST COURSE
TOPOGRAPHIC MAP

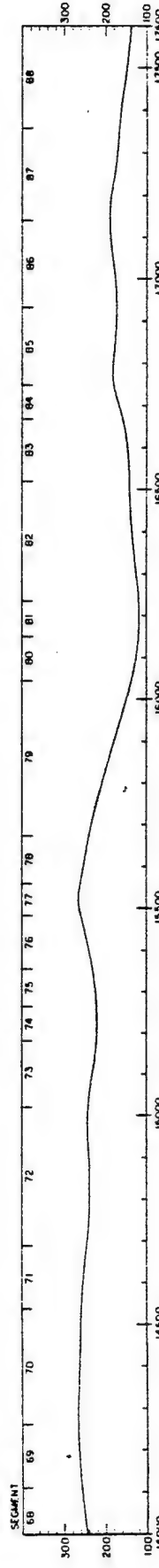
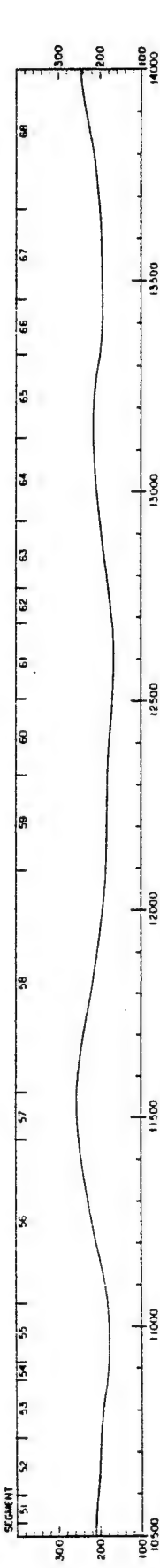
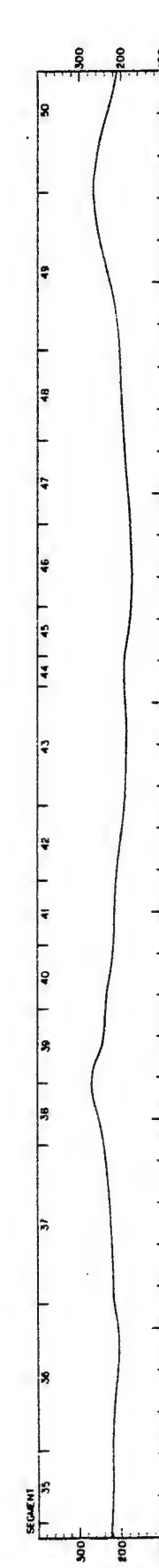
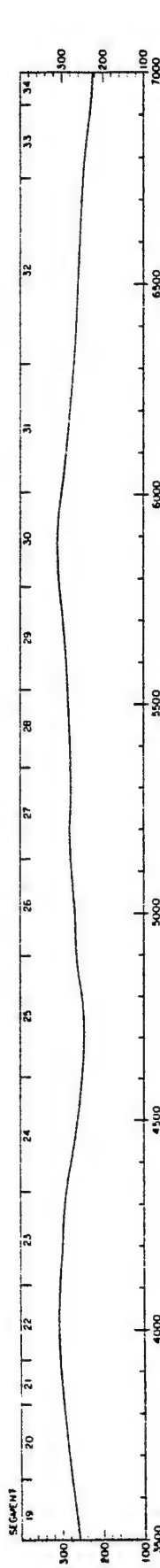
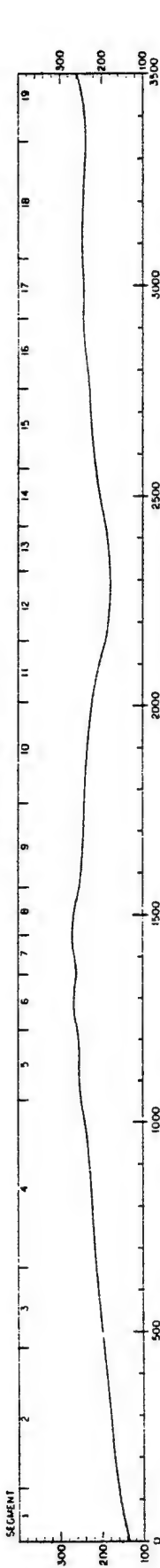
Scale	1:50,000
Projection	Universal Transverse Mercator
Zone	18N
Datum	NAD 83
Units	Meters
Contour Interval	5 Meters
Spot Elevation Interval	1 Meter
Map Sheet Number	18N 01 001



ABERDEEN PROVING GROUNDS
CHURCHVILLE TEST COURSE



ELEVATION VIEW



COURSE DISTANCE (FEET)
COUNTER-CLOCKWISE TRAVERSEL

84-11-14

defined for each.

- o Homopolar, Generator Driven (parallel/series systems)
- o Homopolar, Alternator Driven (parallel/series systems)
- o Brushless DC, Alternator Driven (low speed-high torque/high speed-low torque)
- o High Frequency Induction, Alternator Driven
- o Commutated DC, Alternator Driven

E.2.6 Performance Limitation

Several inputs not available for the internal data files are required of the user. These include:

- o Maximum (final) Forward Velocity
- o Maximum Forward Acceleration
- o Maximum Deceleration
- o Maximum Lateral Acceleration

E.3 Vehicle Mission Simulation and Analysis

E.3.1 Electric Drive Performance

The emphasis of this subprogram is the steady state analysis of electrically driven vehicles on a segment by segment basis as the vehicle maneuvers over a given course. It is best suited for analysis of steady state electric drive mission performance, particularly if the course of the mission is relatively uniform, and the segments of each course segment are lengthy in comparison to the time it takes the vehicle to traverse them. Detailed sprocket data (see Figure E.4-2) for each track is available to the user, as well as the equivalent sprocket motor dynamics. Motor and system electrical data is also generated, including voltages, currents, and power, including the net power which must be supplied (or absorbed) to both sprocket motors from the bus. These parameters aid in the evaluation of the system operation during turns and regenerative conditions, and allow the magnitudes and directions of system energy flow to be easily monitored. Net drive efficiency along with generated and lost energy are also provided to determine if overall system performance is within acceptable limits. These energies are reflected in terms of required prime mover power and the resultant fuel consumption. For further mission analysis, fuel economy is calculated, and a range estimate based on a specified vehicle fuel tank volume is made.

E.3.2 Vehicle Acceleration Performance

For any vehicle mission, this subprogram provides the user with the most realistic assessment of vehicle performance over any course conditions. All vehicle transitory states (i.e., acceleration, deceleration, braking) between constant velocity conditions are considered in order to yield smooth vehicle motion throughout the course. The subprogram is specified for overall mission analysis rather than an electric drive component evaluation. This is evident in the printed output page (see Figure E.4-3) which provides detailed acceleration/deceleration information, but no internal electric drive data. The complete electric drive models are utilized for this analysis but the transitory nature of the vehicle drive during the test periods makes it difficult to extract any meaningful output of the electrical parameters.

As with the Electric Drive Performance subprogram, power supplied by the prime mover is determined along with the system energy which is generated and lost. Fuel consumption data is presented as well as the full fuel tank range estimate. Cumulative mission information is available for each segment of the course, and can provide a useful means of evaluating incremental mission performance.

E.4 Program Outputs

Examples of the information which each of the subprograms outputs to the user are given in Figures E.4-2 to E.4-5. Figure E.4-1 is the main program header sheet that is included with each run to specify which subprogram is in use and which echoes all the data that has been input by the user.

ELECTRIC VEHICLE MISSION SIMULATION

FMC / NORTHERN ORDINANCE DIVISION
MINNEAPOLIS, MINNESOTA USA

REVISION DATE: 12/10/84
RUN DATE: 5/21/85

ELECTRICALLY DRIVEN, TRACKED VEHICLE PERFORMANCE IS SIMULATED BY THIS PROGRAM. DETAILED ASPECTS OF VEHICLE PERFORMANCE CAN BE INVESTIGATED USING THE FOUR RESIDENT SUB-PROGRAMS LISTED BELOW. THE SUB-PROGRAM IN USE IS IDENTIFIED WITH AN ASTERISK.

- * 1.) ELECTRIC DRIVE PERFORMANCE -
STEADY STATE VEHICLE PERFORMANCE ANALYSIS WITH DETAILED EMPHASIS ON ELECTRIC POWER DRIVE PARAMETERS. ENERGY USAGE, HEAT REJECTION, AND FUEL IMPACT ARE ALSO CALCULATED.
- 2.) VEHICLE ACCELERATION PERFORMANCE -
DYNAMIC VEHICLE PERFORMANCE ANALYSIS WHICH REALISTICALLY SIMULATES GROSS VEHICLE MISSION OVER ALL TERRAIN CONDITIONS. ACCELERATION, DECELERATION, BRAKING AND CONSTANT VELOCITY CONDITIONS ARE CONSIDERED.
- 3.) ACCELERATION DYNAMICS ROUTINE -
DETAILED ANALYSIS OF FULL POWER VEHICLE ACCELERATION DURING TURNING AND NON-TURNING MANEUVERS ON USER SELECTED GRADES AND SURFACES. INCREMENTAL DYNAMIC PARAMETERS ARE GENERATED AND TABULATED.
- 4.) REDUCTION DYNAMICS ROUTINE -
DETAILED ANALYSIS OF SPEED/TORQUE LOADING OF ALL VEHICLE POWER TRAIN REDUCTION ELEMENTS. FINAL SPROCKET DRIVES AND DIESEL ENGINE INTERFACE ARE INCLUDED IN ANALYSIS.

COURSE DATA	VEHICLE DATA	ENGINE DATA	ELECTRIC DRIVE DATA
COURSE: CHURCHVILLE	GROSS VEHICLE WEIGHT, tons= 19.5	ENGINE: VTA-903	TYPE: HoPol P-A
SURFACE: COMPACTED SOIL	FRONTAL AREA, sq. ft.= 57	MAX. POWER, hp= 500	PEAK MOTOR EFF., %= 90
COEFFICIENT OF FRICTION= .7	COEFFICIENT OF DRAG= 1	MAX. SPEED, rpm= 2960	ALTERNATOR EFF., %= 90
PERFORMANCE LIMITS	TREAD WIDTH, in.= 92.5	SPEED FOR MIN. FUEL, rpm= 2100	RECTIFIER EFF., %= 99.5
	TRACK LENGTH, in.= 150	COOLING LOSSES, % Ghp= 4	ALTERNATOR F.F., %= 90
MAX. COURSE VELOCITY, mph= 45	TRACK PITCH, in.= 6.03	INLET/EXHAUST LOSSES, % Ghp= 1.5	MOTOR I.M, V/Krpm-A= .005
MAX. LAT. ACCEL., g's= .5	NUMBER OF SPROCKET TEETH= 11	AUXILIARY POWER, hp= 6	
	ROLLING RESISTANCE, lb. per ton= 100	FUEL CAPACITY, gal.= 175	
	MAXIMUM VELOCITY, mph= 45	SCHEDULING: VARIABLE	

***** ELECTRIC DRIVE PERFORMANCE *****

***** MISSION PARAMETERS *****

COURSE	SURFACE	MAX. VELOCITY (mph)	MAX. LAT. ACCEL. (g's)	VEHICLE	ENGINE	ENGINE SCHEDULING	ELECTRIC DRIVE TYPE
CHURCHVILLE	COMPACTED SOIL	45.00	0.50	19.5 TON	VTA-903	VARIABLE	HoPol P-A

***** MISSION COURSE DATA *****

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. FORWARD VELOCITY (mph)	RANGE ESTIMATE (miles)
1	1	244	10.7	100	8.99	244	8.99	18.51	130.85

***** VEHICLE PERFORMANCE DATA *****

FORWARD VELOCITY (mph)	TRACTIVE EFFORT (k-lbs)	LATERAL ACCELERATION (g's)	HORSEPOWER (hp)	TORQUE (ft-lb)	INNER SPROCKET SPEED (rpm)	HORSEPOWER (hp)	OUTER SPROCKET SPEED (rpm)	TORQUE (ft-lb)	NET DRIVE EFFICIENCY (%)
18.50	6.15	0.229	-103.91	-1978.51	275.84	440.67	313.21	7389.36	67.70

***** ENGINE / ENERGY DATA *****

HORSEPOWER GENERATED (hp)	SEGMENT ENERGY (btu)	CUMULATIVE ENERGY USED (btu)	SEGMENT ENERGY LOSS (btu)	ENGINE SPEED (rpm)	FUEL CONSUMPTION (lb/hr)	FUEL REMAINING (gal.)	FUEL ECONOMY (mpg)
497.46	3161.99	3161.99	1021.40	2587.32	194.97	174.94	0.75

***** ELECTRIC DRIVE DATA *****

ALTERNATOR				INNER SPROCKET MOTOR				OUTER SPROCKET MOTOR			
SPEED (rpm)	VOLTAGE (volts)	CURRENT (amps)	POWER (kVA)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (kw)	SPEED (rpm)	TORQUE (ft-lb)	HORSEPOWER (hp)	FIELD POWER (kw)
11953.44	7.33	45550.83	300.83	4597.35	-115.15	-100.79	17.0	5220.23	457.07	454.30	13.2

MISSION PARAMETERS

MAX. FWD. ACCEL. (g's)		MAX. LAT. ACCEL. (g's)		VEHICLE		ENGINE		SCHEDULING		ELECTRIC DRIVE TYPE	
45.00		0.50		19.5 TON		VTA-903		CONSTANT		HoPol P-6	

COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. SEGMENT VELOCITY (mph)	AVG. MISSION VELOCITY (mph)
1	1	587.0	-0.10	0.0	16.93	587.00	16.93	23.64	23.64

VEHICLE PERFORMANCE DATA

*** CONSTANT VELOCITY ***

LATERAL ACCELERATION (g's)		FORWARD VELOCITY (mph)		AVERAGE		AVERAGE		*** DECELERATION ***	
0.00		33.08		ACCELERATION (g's)		DISTANCE (ft)		DECELERATION (g's)	
				0.09		580.72		0.00	
				0.13				0.00	
								0.00	

ENERGY DATA

ENERGY GENERATED (btu)		ENERGY LOSSES (btu)		ENERGY REGENERATED (btu)		BRAKING ENERGY (btu)		CUMULATIVE ENERGY USED (btu)		RANGE ESTIMATE (miles)		AVG. FUEL CONSUMPTION (lb/hr)		SEGMENT FUEL CONSUMED (gal)		FUEL REMAINING (gal)		FUEL ECONOMY (mpg)	
5717.46		2152.69		0.00		0.00		5717.46		172.03		189.46		0.11		174.89		0.98	

MISSION PARAMETERS

MAX. FWD. ACCEL. (g's)		MAX. LAT. ACCEL. (g's)		VEHICLE		ENGINE		SCHEDULING		ELECTRIC DRIVE TYPE	
45.00		0.50		19.5 TON		VTA-903		CONSTANT		HoPol P-6	

COURSE DATA

LAP NO. (#)	SEGMENT NO. (#)	DISTANCE (ft)	GRADE (%)	RADIUS (ft)	TIME (sec)	CUMULATIVE DISTANCE (ft)	CUMULATIVE TIME (sec)	AVG. SEGMENT VELOCITY (mph)	AVG. MISSION VELOCITY (mph)
1	2	1173.0	-0.30	0.0	20.83	1760.00	37.76	38.39	31.78

VEHICLE PERFORMANCE DATA

*** CONSTANT VELOCITY ***

LATERAL ACCELERATION (g's)		FORWARD VELOCITY (mph)		AVERAGE		AVERAGE		*** DECELERATION ***	
0.00		42.03		ACCELERATION (g's)		DISTANCE (ft)		DECELERATION (g's)	
				0.02		1171.32		0.00	
				0.03				0.00	
								0.00	

ENERGY DATA

ENERGY GENERATED (btu)		ENERGY LOSSES (btu)		ENERGY REGENERATED (btu)		BRAKING ENERGY (btu)		CUMULATIVE ENERGY USED (btu)		RANGE ESTIMATE (miles)		AVG. FUEL CONSUMPTION (lb/hr)		SEGMENT FUEL CONSUMED (gal)		FUEL REMAINING (gal)		FUEL ECONOMY (mpg)	
6825.26		2473.95		0.00		0.00		12572.72		235.20		186.30		0.13		174.75		1.34	

VEHICLE ACCELERATION DYNAMICS

MISSION PARAMETERS

SURFACE	GRADE	RADIUS	INITIAL	FINAL	MAX. FWD.	MAX. LAT.	VEHICLE	ENGINE	ELECTRIC
COMPACTED SOIL	(%)	(ft)	VELOCITY	VELOCITY	ACCEL.	ACCEL.	19.5 TON	VTA-903	DRIVE TYPE
	20.0	600	(mph)	(mph)	(g's)	(g's)			
			0.10	13.70	0.50	0.50			HoPol 8-A

VEHICLE / SPROCKET DATA

TIME	VELOCITY	DISTANCE	TRACTIVE	FORWARD	INNER SPROCKET				OUTER SPROCKET			
					ACCEL.	HORSEPOWER	SPEED	TORQUE	HORSEPOWER	SPEED	TORQUE	
(sec)	(mph)	(ft)	EFFORT	(g's)	(Hp)	(rpm)	(ft-lb)	(ft-lb)	(Hp)	(rpm)	(ft-lb)	
0.1	1.00	0.08	27.99	0.410	3.64	1.58	12127	12500	3.83	1.61	12500	
0.2	1.83	0.29	26.64	0.380	34.60	15.75	11535	11908	36.48	16.09	11908	
0.3	2.60	0.61	25.30	0.350	60.21	28.90	10943	11316	63.59	29.51	11316	
0.4	3.33	1.05	24.40	0.330	82.35	41.00	10549	10921	87.08	41.88	10921	
0.5	3.99	1.59	23.06	0.300	99.36	52.41	9957	10330	105.29	53.53	10330	
0.6	4.60	2.22	22.16	0.280	114.32	62.79	9563	9935	121.31	64.13	9935	
0.7	5.17	2.93	21.26	0.260	126.51	72.47	9168	9541	134.47	74.02	9541	
0.8	5.70	3.73	20.37	0.240	136.09	81.46	8774	9147	144.90	83.20	9147	
0.9	6.18	4.60	19.47	0.220	143.22	89.76	8380	8753	152.78	91.68	8753	
1.0	6.62	5.54	18.57	0.200	148.05	97.37	7986	8358	158.27	97.45	8358	
1.5	8.65	11.14	17.90	0.185	152.69	104.29	7690	8063	163.52	106.52	8063	
2.0	9.91	17.95	14.77	0.115	163.74	136.28	6311	6683	177.12	139.19	6683	
2.5	10.76	25.53	13.07	0.077	165.39	156.16	5562	5935	180.24	159.50	5935	
3.0	11.36	33.64	12.08	0.055	165.51	169.48	5129	5502	181.34	173.10	5502	
3.5	11.81	42.14	11.46	0.041	165.42	178.99	4854	5227	181.93	182.81	5227	
4.0	12.16	50.94	11.05	0.032	165.70	186.08	4677	5050	182.73	190.05	5050	
4.5	12.44	59.96	10.74	0.025	165.61	191.61	4539	4912	183.04	195.70	4912	
5.0	12.66	69.16	10.52	0.020	165.68	195.93	4441	4814	183.42	200.12	4814	
5.5	12.83	78.51	10.34	0.016	165.62	199.39	4363	4735	183.61	203.65	4735	
6.0	12.98	87.98	10.21	0.013	165.65	202.16	4304	4676	183.85	206.48	4676	
6.5	13.10	97.54	10.12	0.011	165.97	204.40	4265	4637	184.33	208.77	4637	
7.0	13.20	107.18	10.03	0.009	165.97	206.31	4225	4598	184.47	210.72	4598	
7.5	13.28	116.90	9.98	0.008	166.45	207.86	4206	4578	185.07	212.31	4578	
8.0	13.35	126.66	9.89	0.006	165.99	209.25	4166	4539	184.70	213.72	4539	
8.5	13.40	136.48	9.85	0.005	166.03	210.28	4147	4519	184.82	214.78	4519	
9.0	13.45	146.32	9.80	0.004	165.92	211.15	4127	4500	184.77	215.66	4500	
9.5	13.49	156.20	9.80	0.004	166.47	211.84	4127	4500	185.38	216.37	4500	
10.0	13.53	166.11	9.76	0.003	166.22	212.53	4108	4480	185.17	217.07	4480	
11.0	13.57	185.99	9.71	0.002	165.82	213.05	4088	4461	184.81	217.60	4461	
12.0	13.61	205.92	9.72	0.002	166.36	213.74	4088	4461	185.41	218.31	4461	
13.0	13.64	225.91	9.67	0.001	166.10	214.43	4068	4441	185.19	219.02	4441	
14.0	13.66	245.93	9.67	0.001	166.37	214.78	4068	4441	185.49	219.37	4441	
15.0	13.68	265.98	9.67	0.001	166.64	215.13	4068	4441	185.79	219.72	4441	
16.0	13.68	285.98	9.67	0.000	166.91	215.47	4068	4441	186.09	220.08	4441	

GEAR REDUCTION DYNAMICS

MISSION PARAMETERS

SEG. NO. (1) SURFACE GRADE (%) FORWARD VELOCITY (mph) MAX. LAT. ACCEL. (g's) ENGINE VEHICLE 19.5 TON ELECTRIC DRIVE TYPE HoPol S-G

GEARBOX DATA

OUTER SPROCKET				INNER SPROCKET				DIESEL INTERFACE			
GEAR	SPEED (rpm)	TORQUE (ft-lb)	GEAR	SPEED (rpm)	TORQUE (ft-lb)	GEAR	SPEED (rpm)	TORQUE (ft-lb)	GEAR	SPEED (rpm)	TORQUE (ft-lb)
GB2-A	4458.4	443.0	GB2-A	3926.4	-119.1	GB1-A	2592.0	1009.9	GB1-A	2592.0	1009.9
GB2-B	1486.1	1329.0	GB2-B	1308.8	-357.2	GB1-B	5184.0	504.9	GB1-B	5184.0	504.9
GB2-C	743.1	2658.0	GB2-C	654.4	-714.4	GB1-C	11975.0	218.6	GB1-C	11975.0	218.6
GB2-D	267.5	7383.4	GB2-D	235.6	-1984.4						

MISSION PARAMETERS

SEG. NO. (2) SURFACE GRADE (%) FORWARD VELOCITY (mph) MAX. LAT. ACCEL. (g's) ENGINE VEHICLE 19.5 TON ELECTRIC DRIVE TYPE HoPol S-G

GEARBOX DATA

OUTER SPROCKET				INNER SPROCKET				DIESEL INTERFACE			
GEAR	SPEED (rpm)	TORQUE (ft-lb)	GEAR	SPEED (rpm)	TORQUE (ft-lb)	GEAR	SPEED (rpm)	TORQUE (ft-lb)	GEAR	SPEED (rpm)	TORQUE (ft-lb)
GB2-A	5094.5	166.5	GB2-A	5094.5	166.5	GB1-A	2596.7	1010.0	GB1-A	2596.7	1010.0
GB2-B	1698.2	499.4	GB2-B	1698.2	499.4	GB1-B	5193.4	505.0	GB1-B	5193.4	505.0
GB2-C	849.1	998.8	GB2-C	849.1	998.8	GB1-C	11996.8	218.6	GB1-C	11996.8	218.6
GB2-D	305.7	2774.5	GB2-D	305.7	2774.5						

MISSION PARAMETERS

SEG. NO. (3) SURFACE GRADE (%) FORWARD VELOCITY (mph) MAX. LAT. ACCEL. (g's) ENGINE VEHICLE 19.5 TON ELECTRIC DRIVE TYPE HoPol S-G

GEARBOX DATA

OUTER SPROCKET				INNER SPROCKET				DIESEL INTERFACE			
GEAR	SPEED (rpm)	TORQUE (ft-lb)	GEAR	SPEED (rpm)	TORQUE (ft-lb)	GEAR	SPEED (rpm)	TORQUE (ft-lb)	GEAR	SPEED (rpm)	TORQUE (ft-lb)
GB2-A	11940.3	-19.8	GB2-A	11940.3	-19.8	GB1-A	2596.7	-11.2	GB1-A	2596.7	-11.2
GB2-B	3980.1	-59.3	GB2-B	3980.1	-59.3	GB1-B	5193.4	-5.6	GB1-B	5193.4	-5.6
GB2-C	1990.0	-118.6	GB2-C	1990.0	-118.6	GB1-C	11996.8	-2.4	GB1-C	11996.8	-2.4
GB2-D	716.4	-329.5	GB2-D	716.4	-329.5						

APENDIX F

CONTRACT VEHICLE AND PROPULSION
SYSTEM SPECIFICATIONS

ATTACHMENT 1

SPECIFICATIONS

1. General Vehicle Specifications (Fig. 2):

Frontal Area	6.34 sq m (68.25 ft ²)
Gross Vehicle Weight	36.3 ton (40 ton)
Vehicle Top Speed (Governed)	73 Km/hr (45 mph)
Track Length (forward to aft roadwheel centerline)	4650 mm (183.07 in.)
Distance between track longitudinal centerline	2790 mm (109.84 in)
Track Width	580 mm (22.83 in.)

2. Propulsion System Specifications:

a. Transmission: (Electric Drive System)

The drive system shall provide automatic speed ration control and inhibitors to prevent engine overspeed. Maximum output torque required shall be sufficient to generate a tractive effort of 427,000 Newtons, Reverse - 427,000 Newtons. There shall be tactile feedback to the driver when the transmission is in forward or reverse operational mode. The power train shall provide for safe, predictable performance for extended periods at speeds below 5 Km/hr.

b. Steer System:

A regenerative speed control system is required. Differential torque between sides shall be equal to maximum steer torque. Pivot steer capability on hard surface shall be 7 revolutions/min. The steering controls shall remain operative in the event of engine failure or vehicle towing. The steer system shall be capable of accepting full engine power.

c. Coding Capability:

Capable of continuous tractive effort operation of at least 250,000 N.

d. Braking:

The vehicle shall be capable of a deceleration rate from maximum speed on level hard surface road at least 7 m/sec² (peak) and 5 m/sec² (avg.). The vehicle shall be capable of an included hold with engine off on at least a 60% slope. The vehicle shall be capable of at least 25 stops from 60 Km/hr @ 5 m/sec² @ 3 minute intervals. The braking functions shall be accomplished by two separate mechanisms to allow redundancy for emergency purposes.

ATTACHMENT 1 (Contd)

e. Electric/Hydraulic Power Capability:

Continuous operation of all vehicle electrical and hydraulic systems shall be at least 7 Kw, to include silent watch - the silent watch is non-mobile, with noise, light, and smoke discipline. The above power requirement covers turret hydraulic, radio and other electrical needs, compartment ventilation and NBC countermeasure equipment. Electrical and hydraulic power sources must be capable of operating independently or in parallel in a stable self regulating manner. Average auxiliary power usage is 3.5 Kw.

f. Speed on Grades:

The propulsion system shall be capable of sustaining forward vehicles speeds on hard surface roads and grades as defined in Figure 1.

g. Acceleration:

The vehicle shall be capable of acceleration on dry level surface from idle, from application of the throttle, in the forward direction from zero to 32.2 Km/hr (20 mph) in seven seconds; and in reverse direction from zero to 16 Km/hr (10 mph), in five seconds. Assume no "throttle" linkage delay.

h. Engine: See figures 4 and 5.

i. Shock:

The electric drive system must be able to withstand a 15-g shock load in any direction.

ATTACHMENT 2

SPECIFICATIONS

1. General Vehicle Specifications (Fig. 3):

Frontal Area	5.3 sq m (57 ft ²)
Gross Vehicle Weight	17.6 ton (19.5 ton)
Vehicle Top Speed (Governed)	73 Km/hr (45 mph)
Track Length (forward to aft roadwheel centerline)	3810 mm (150.0 in)
Distance between track longitudinal centerline	2350 mm (92.52 in)
Track Width	445 mm (17.52 in)

2. Propulsion System Specifications:

a. Transmission: (Electric Drive System)

The drive system shall provide automatic speed ratio control and inhibitors to prevent engine overspeed. Maximum output torque required shall be sufficient to generate a tractive effort of 208,000 Newtons, Reverse - 208,000 Newtons. There shall be tactile feedback to the driver when the transmission is in forward or reverse operational mode. The power train shall provide for safe, predictable performance for extended periods at speeds below 5 Km/hr.

b. Steer System:

A regenerative speed control system is required. Differential torque between sides shall be equal to maximum steer torque. Pivot steer capability on hard surface shall be 7 revolutions/min. The steering controls shall remain operative in the event of engine failure or vehicle towing. The steer system shall be capable of accepting full engine power.

c. Coding Capability:

Capable of continuous tractive effort operation of at least 121,500 N.

d. Braking:

The vehicle shall be capable of a deceleration rate from maximum speed on level hard surface road at least 7 m/sec² (peak) and 5 m/sec² (avg.). The vehicle shall be capable of an included hold with engine off on at least a 60% slope. The vehicle shall be capable of at least 25 stops from 60 Km/hr @ 5 m/sec² @ 3 minute intervals. The braking functions shall be accomplished by two separate mechanisms to allow redundancy for emergency purposes.

ATTACHMENT 2 (Cont'd)

a. Electric/Hydraulic Power Capability:

Continuous operation of all vehicle electrical and hydraulic systems shall be at least 7 Kw, to include silent watch - the silent watch is non-mobile, with noise, light, and smoke discipline. The above power requirement covers turret hydraulic, radio and other electrical needs, compartment ventilation and NBC countermeasure equipment. Electrical and hydraulic power sources must be capable of operating independently or in parallel in a stable self regulating manner. Average auxiliary power usage is 2.5 Kw.

f. Speed on Grade:

The propulsion system shall be capable of sustaining forward vehicles speeds on hard surface roads and grades as defined in Figure 1.

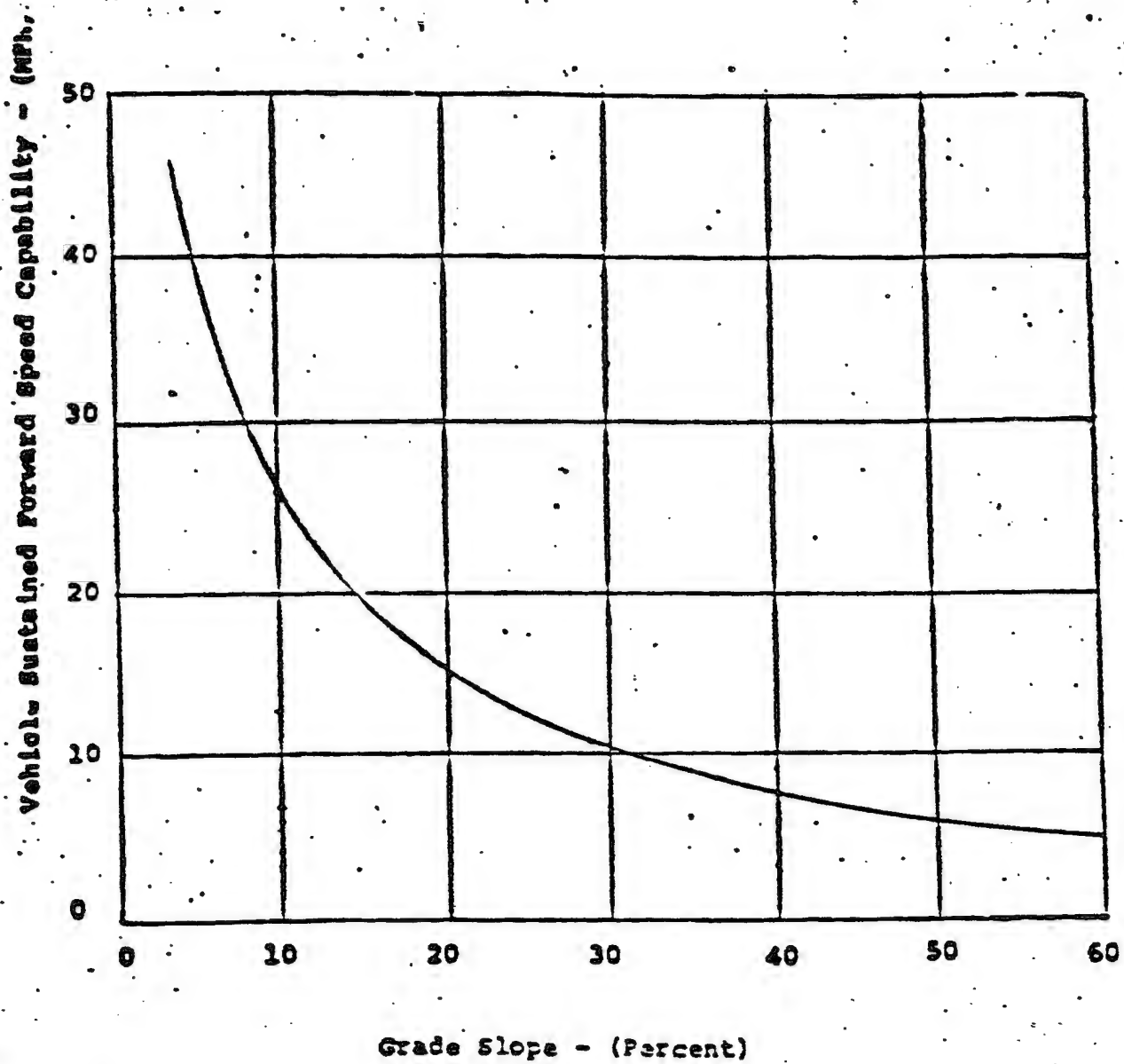
g. Acceleration:

The vehicle shall be capable of acceleration on dry level surface from idle, from application of the throttle, in the forward direction from zero to 32.2 Km/hr (20 mph) in seven seconds; and in reverse direction from zero to 16 Km/hr (10 mph), in five seconds. Assume no "throttle" linkage delay.

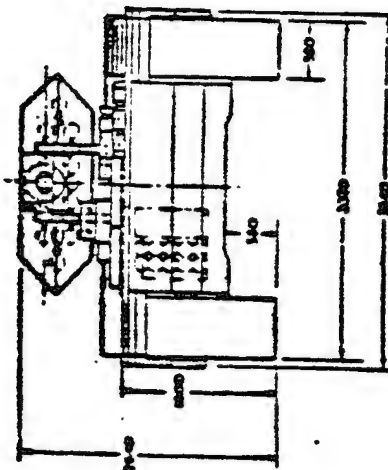
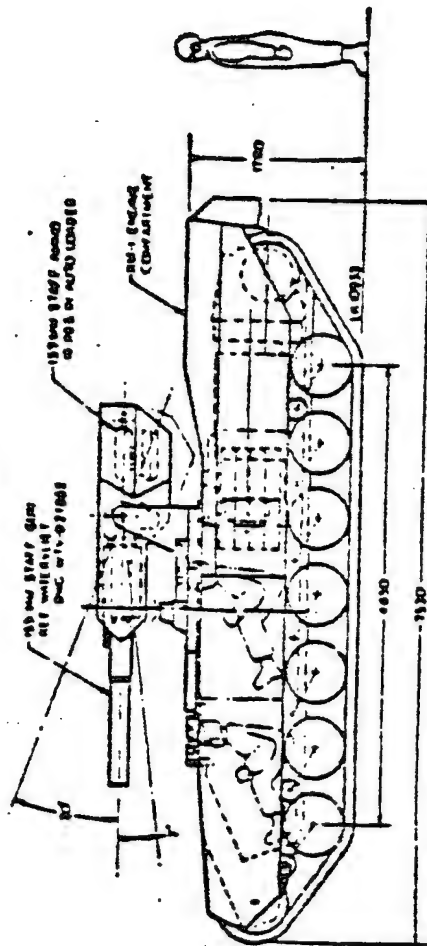
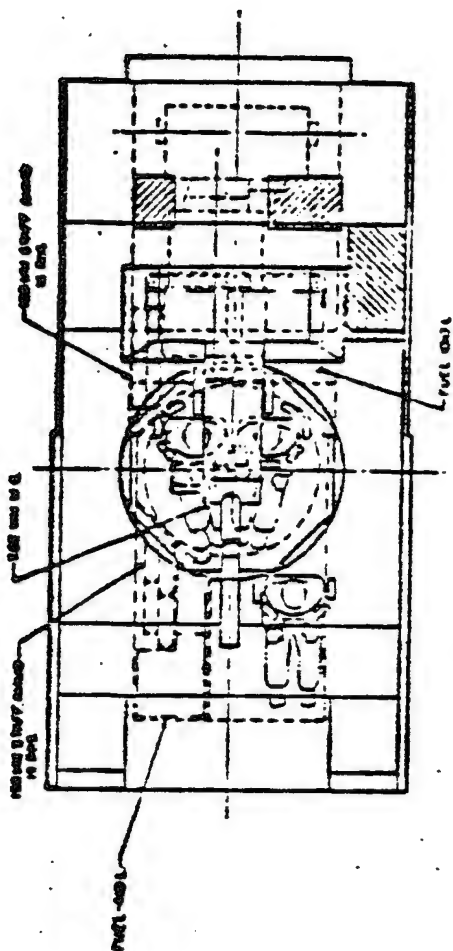
h. Engine: See figures 4 and 5.

i. Shock:

The electric drive system must be able to withstand a 15 g shock load in any direction.



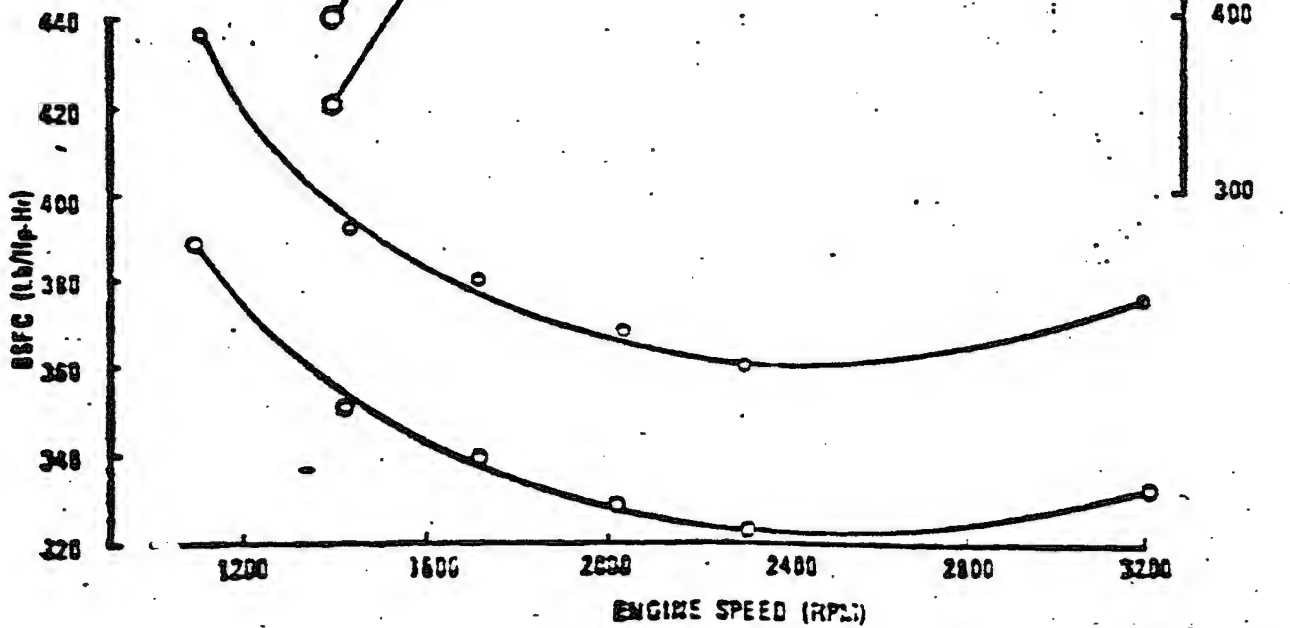
NOTE: Performance shall be measured over hard-surface roads.

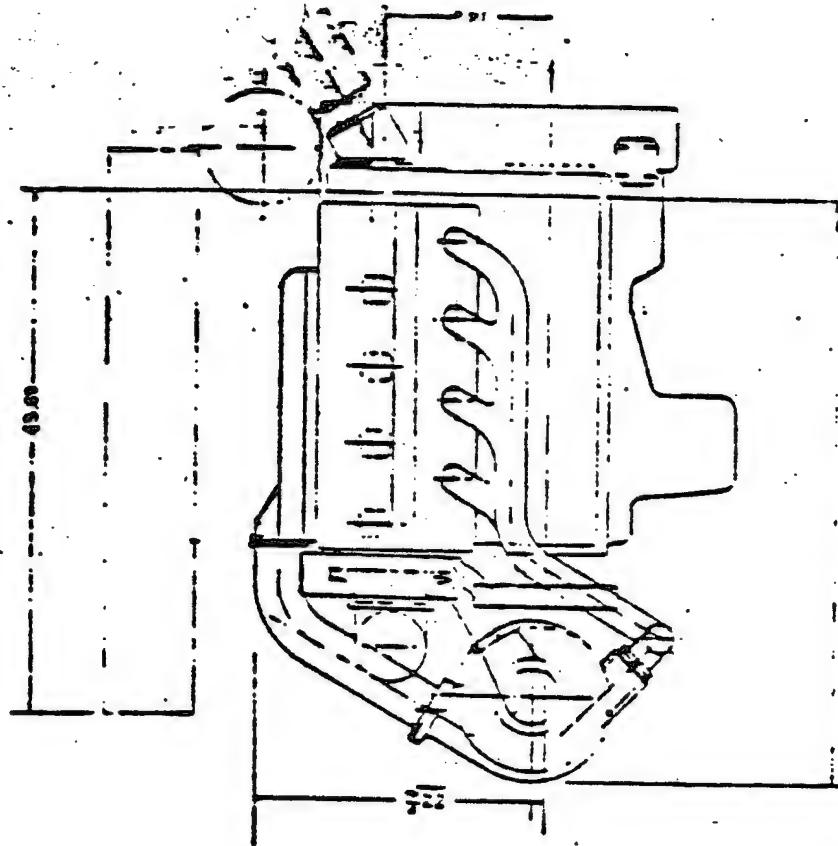
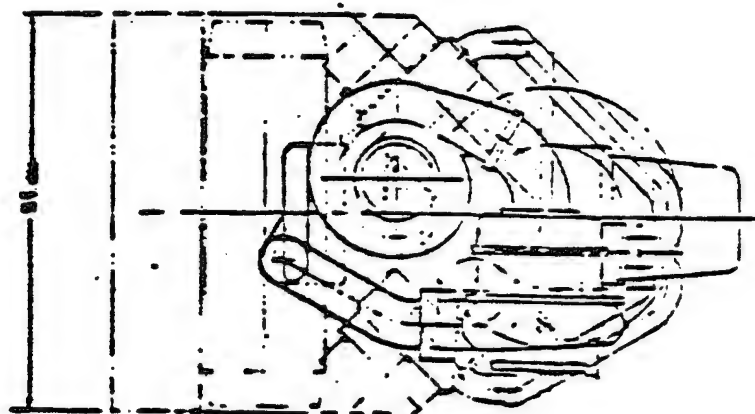


AD 1000
PROJECTION

ASSUMPTIONS:

- FAN HP = 12% GROSS HP





RADIAL TURBOCOMPOUND SYSTEM LAYOUT

AD 1000



CUMMINS ENGINE COMPANY, INC.

Columbus, Indiana 47201

AUTOMOTIVE PERFORMANCE CURVE

BASIC ENGINE MODEL:

VTA-903-T

CURVE NUMBER:

RC-3914-A

ENGINE FAMILY:

CPL CODE:

0383

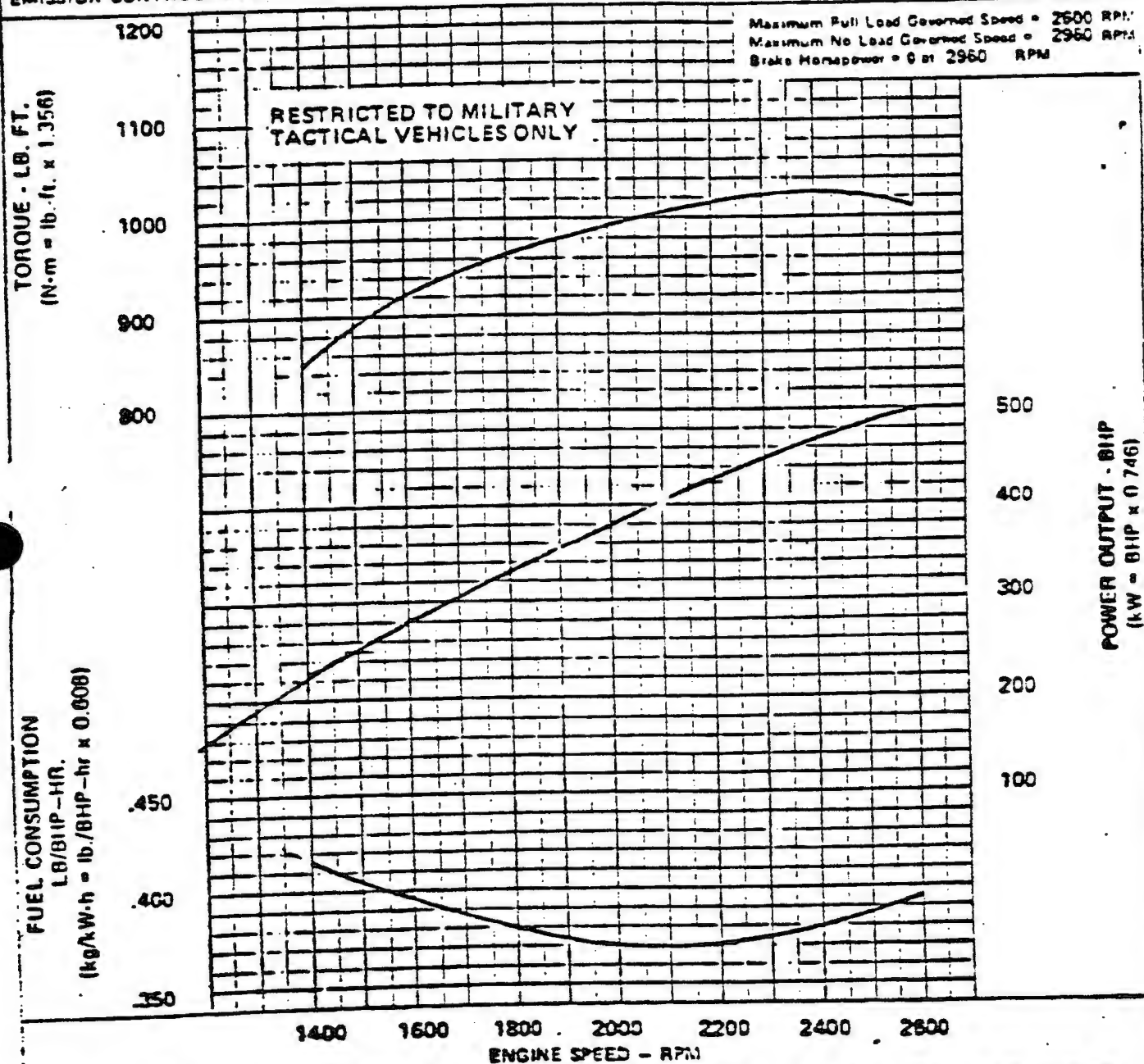
DATE:

4/12/79

BY:

M.L.S.

DISPLACEMENT: 903 in³ (14.8 litre) ASPIRATION: TURBOCHARGED & AFTERCOOLED RATING:
BORE: 5.5 in (140 mm) STROKE: 4.75 in (121 mm) NO. OF CYLINDERS: 8 HF (kW) & RPM
EMISSION CONTROL: A/C FUEL SYSTEM: PT 500 (373) @ 2600



Curves shown above represent engine performance capabilities at SAE standard J815 conditions of 200 ft (7500) altitude (21.00" Hg (725.0 mm Hg) dry barometer), 85°F (29°C) air intake temperature, and 0.35" Hg (9.5 mm Hg) water vapor pressure with No. 2 diesel fuel.

STANDARDS DEPT.

CERTIFIED WITHIN 5%.

S. L. Gaal

CHIEF ENGINEER

propulsion and other system element speeds--1000 rpm
 steamulation input speed.

[illegible]

Figure 1

19.5-Ton Vehicle Performance Requirement

Tractive Effort - Lbs Speed - MPH

27,300	5.0
25,000	5.5
20,000	6.8
15,000	9.1
10,000	13.7
7,500	18.3
5,000	27.4
4,000	34.2
3,042	45.0

TRACTION EFFORT - LBS X 1000

30

25

20

15

10

5

10

20

30

40

50

MPH

40-Ton Vehicle Performance Requirement

Tractive Effort - Lbs Speed - MPH

56,000	4.9
50,000	5.5
45,000	6.1
40,000	6.8
35,000	7.8
30,000	9.1
25,000	11.0
20,000	13.7
15,000	18.3
10,000	27.4
7,500	36.5
6,083	45.0

TRACTION EFFORT - LBS X 1000

60

50

40

30

20

10

10

20

30

40

50

MPH

F-15

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APENDIX G

HOMOPOLAR MACHINE DESCRIPTION

APPENDIX G Homopolar Machine Description

One of the vehicle drive system concepts selected utilizes homopolar (single pole) machines as the propulsive component. These direct current (DC) machines are characterized by the low voltage ($< 50V$) and high current nature of their output and the simplicity which is inherent in their design.

G.1 Homopolar Machine Operation

G.1.1 Voltage Generation

Operation of the homopolar machine is governed by Faraday's Law, which relates the mechanical machine parameters, rotational velocity, and magnetic flux to the voltage produced across the rotor (armature). Specifically, $V \propto Bwr\ell$ where;

V = the voltage generated across the armature

B = the density of the magnetic flux passing through the rotor

w = the rotational velocity of the rotor

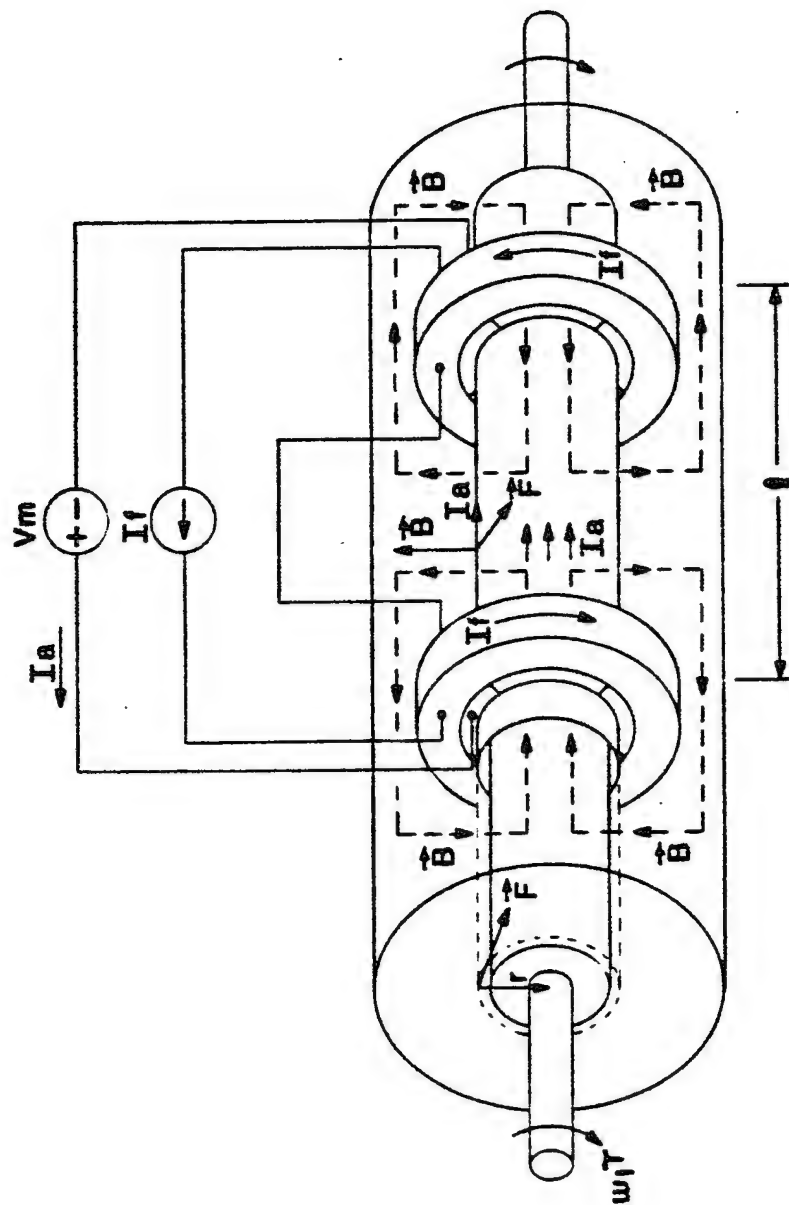
r = the radius of the rotor drum

ℓ = the active machine length (defined as the length of the rotor across which the magnetic flux passes)

The manner in which this relation is satisfied by the machine is shown in Figure G.1.1-1. A solid rotor drum, made of iron or other low magnetic reluctance material, is captured within a thin conducting sleeve which is electrically insulated from the rotor. Electrical connections are made around the periphery at each end of the sleeve by a series of sliding brush contacts. Field coils, which are wound in opposite directions from one another in a circumferential manner, are placed around the rotor near each end. The entire structure is encased within a housing of magnetic material to provide a low reluctance return path for the magnetic flux. During operation as a generator (the homopolar machine acts equally well in a motoring mode) the field coils are excited with a DC current I_f , giving rise to a toroidally oriented magnetic flux about each of the coils. The net flux density which passes across the active length of the rotor (ℓ) is the combined field from each of the field coils. As the rotor is turned at a rotational speed w , the lines of magnetic flux B are constantly cut by the active length ℓ , generating a differential voltage across the rotor drum which satisfies Faraday's Law. This voltage is available at the two brush rings, and if connected to a load, will result in the flow of armature current I .

a

BASIC HOMOPOLAR MACHINE OPERATION



Defining Equations: $d\vec{T} = (\text{Iad}\vec{\Omega} \times \vec{B}) \times \vec{r}$, $[\vec{\Omega} \cdot \text{Iad}\vec{B} \vec{B}]$

$$V_m = V_a + I_a R_a \quad \text{where} \quad V_a = N \frac{d\Phi}{dt} = (-1) |I| \frac{dA}{dt} = |B| \frac{d\phi}{dt} = |B| \frac{d\theta}{dt}$$

$$[V_m - I_B I_w + I_a R_a]$$

G.1.2 Torque Generation

The generation of torque by the homopolar machine is governed by the vector relation $\vec{\tau} = I_a (\vec{l} \times \vec{B}) \times \vec{r}$ and is best understood through consideration of the machine in a motoring mode. With the field coils excited and a potential V_m applied across the armature, an armature current I_a flows proportional to whatever resistance is encountered in the armature circuit. The interaction of the two orthogonal vectors in the directions of the magnetic flux and the armature current give rise to a generated force tangential to the rotor drum. The vector cross product of this force with the radius vector of the machine results in a generated torque about the axis of the rotor. This torque is then transmitted along the shaft.

G.2 Homopolar Machine Characteristics

G.2.1 Machine Losses

Homopolar electrical losses are a function of three components; field coil resistance, armature sleeve resistance, and brush contact potential drop and resistance. Of these, the brush losses are the most significant contributor, due to the resistance vs wear tradeoff which must be analyzed when the brush material is selected. For example, a greater brush force will accelerate brush wear, but will result in a lower resistance and less heating. Lower heat dissipation then helps to lengthen brush life. Active brush cooling helps to reduce some of these factors significantly. Mechanical losses are those normally associated with rotary machinery; i.e., friction and windage. These losses are most prevalent in the machine, and account for the majority of the total losses, particularly if there is little electrical load.

G.2.2 Speed/Torque Characteristics

Electrical machines are characterized by the speed vs torque profile which defines the operating limits at any particular load. A representative curve for a homopolar machine is given in Figure G.2.2-1. The primary machine limitation is thermal rather than magnetic saturation or reaction torque demagnetization (as with permanent magnet DC motors). As long as adequate heat removal is provided, the homopolar machine can deliver rated torque over the full speed range of the machine. Higher, noncontinuous torques at stall or very low speeds are also attainable and can be maintained with sufficient cooling. Stall torque levels are ultimately limited by brush current density, which coupled with the rotor tip speed, for an envelope which defines the maximum transient load.

G.2.3 Homopolar Gain/Control

A primary advantage of homopolar machines is the ability to control their operation through excitation of the field windings

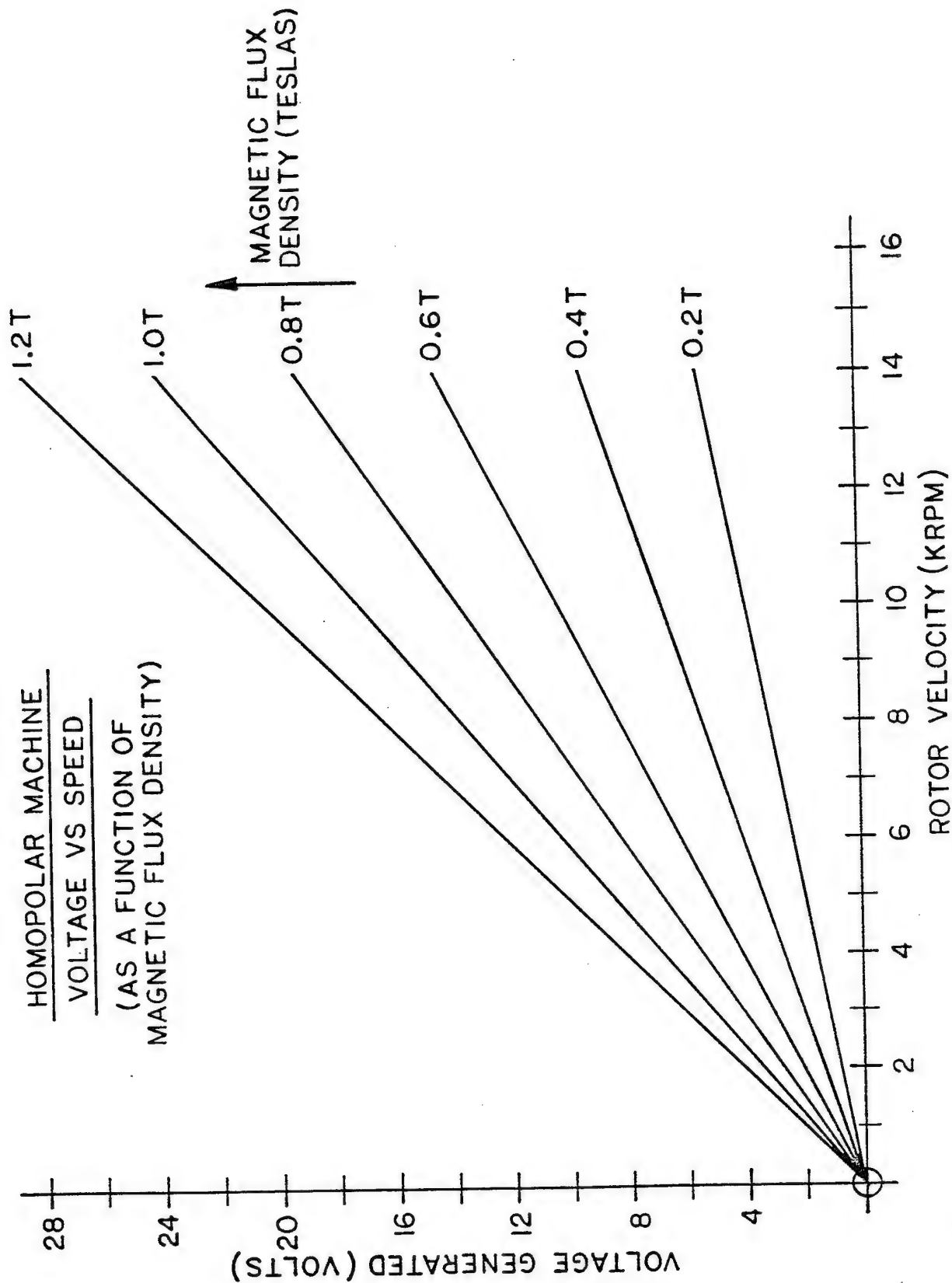
at a much reduced power level. This is in contrast to all AC drive systems which require that a series controller capable of handling the entire motor power be used to generate the necessary AC waveforms. Homopolar machine gain is defined as the ratio of the output power (mechanical for the motoring mode, electrical for the generating mode) to the full excitation power of the field coils. Present homopolar designs yield gains on the order of 25. The method of control is best demonstrated by Figure G.2.3-1, which presents a family of linear speed vs voltage curves. Due to the simplicity of construction and single pole nature of the machine, generated armature voltage is a linear function of rotational velocity. The magnitude of the voltage is controlled by the level of magnetic flux in the machine. Since the flux level is directly proportional to the field current provided, a control parameter for machine speed is realized. In a similar manner, as shown in Figure G.2.3-2, the armature torque generated is a linear function of the armature current and the flux level. Hence torque control is also realized through this same control parameter. In a system which incorporates a homopolar motor and a generator, both speed and torque control are available to the user.

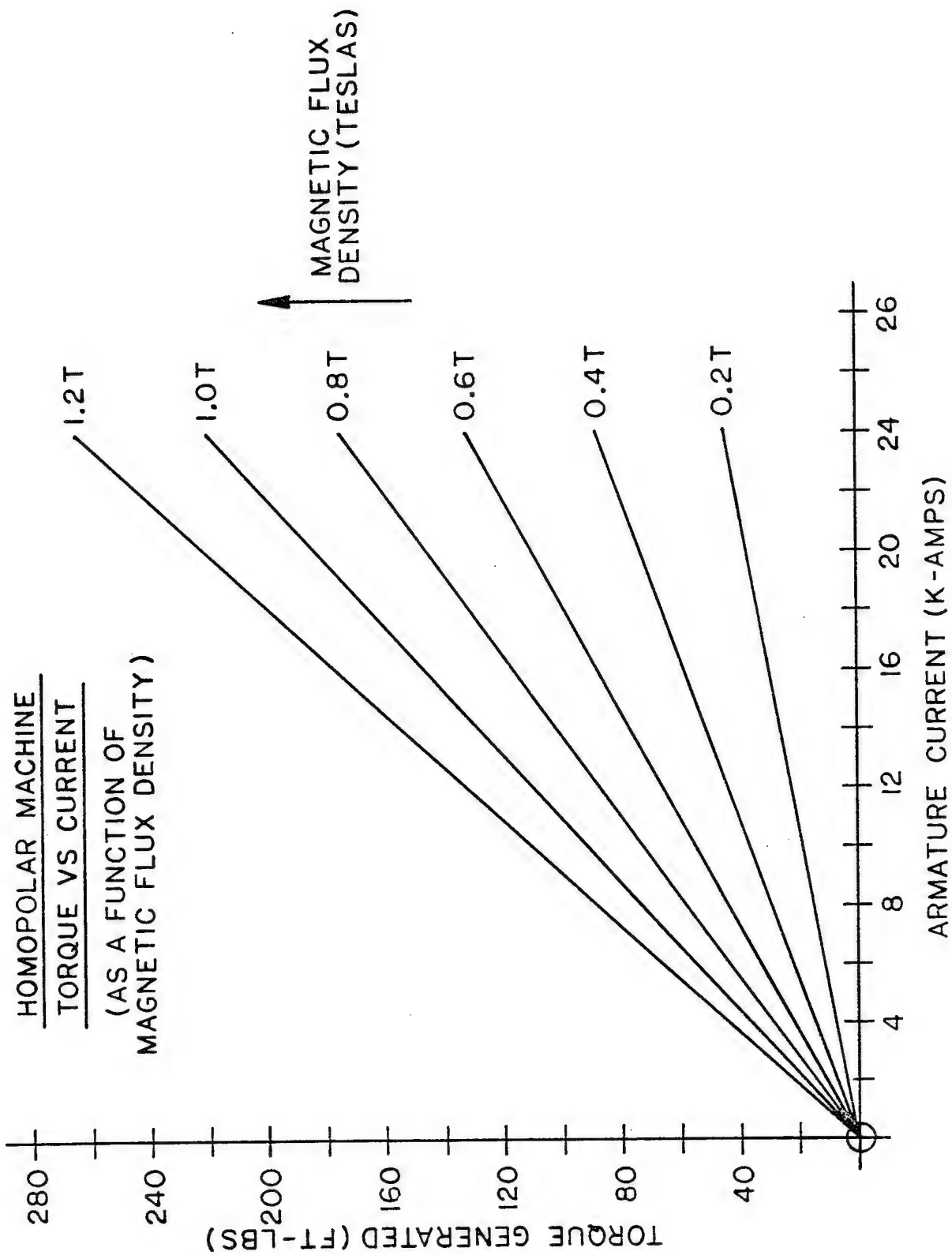
G.2.4 Power Density

Power densities of homopolar machines are moderate in comparison with those of competing technologies. Although significantly better than those of conventional DC machines or industrial AC induction motors, homopolar power densities are not as great as those of machines excited by high frequency AC (i.e., high frequency synchronous or hybrid, brushless machines). This is due in part to the low induction level of materials available and thus the amount of magnetic material required to carry the necessary flux levels. It should be realized, however, that if the weight and volume requirements of the series controller required by each of the AC systems is incorporated into an overall system weight for each of the alternate technology machines, a more equitable comparison is achieved. In such a comparison the power density of the homopolar system is competitive.

G.2.5 Thermal Requirements

The homopolar machines recommended for use as vehicle propulsive elements require liquid cooling for proper operation under normal vehicle loads. This is also true for other high performance technologies (i.e., high frequency AC driven machines). Internal cooling of the homopolar machine rotor drum and brush assemblies are flood cooled, and coolant is circulated through each of the field coils. There is no requirement regarding the ion content of the coolant due to the low potentials which exist within the machine. Precautions, however, should be taken to maintain coolant cleanliness consistent with that required by machines of similar precision.





G.2.6. Rotor Inertia

Rotor inertia of drum configured homopolar machines are competitive with all alternate technology machines and in many cases, such as with large diameter brushless motors (LSHT), are significantly better. Rotor magnetic material mass is the primary influence on this parameter due to the requirement of a complete flux circuit path. Several innovative inertia reduction techniques have been proposed which could ultimately reduce homopolar inertias to less than 25 percent of present designs, resulting in extremely responsive high power machines with servo-drive applications.

APPENDIX H

AC MACHINES OPERATION

H.1 General

In this section, induction, synchronous, and permanent magnet machines are briefly described in terms of their operation.

H.2 Induction Motors. Induction motors are probably the most universal of all motors in present use. They are characterized by extreme simplicity, very rugged construction, high reliability, and low manufacturing cost. AC induction motors can be designed to operate over wide frequency extremes and are very tolerant to waveshape (although reasonable sine waves are preferable), and applied voltage variations. They can be easily designed for single, two, or three or more phased operations. While single-phased motors are not easily reversible, three-phased designs can be reversed electrically.

Operation of induction motors is best described by transformer theory. For simple example purposes, the stator winding can be considered as the primary winding and the rotor the secondary winding. However, the rotor winding is essentially a number of parallel, shorted turns. Thus, voltage so induced across the airgap causes a voltage and appropriate current to circulate in the rotor windings. This rotor current produces a reactive force which opposes the stator current, producing rotation of the armature which is attached to the output shaft. The motor/transformer analogy, however, is no longer valid when the airgap is considered. In a well-designed multiphase power transformer, the airgap is made as small as possible to minimize the loss in power conversion from the primary to secondary winding. In the induction motor, the airgap must provide a correct balance of induced flux in the rotor and airgap loss. Due to the series relationship of the motor windings and the airgap, and the low resistance of the rotor windings, large currents flow in the rotor conductors when small voltages are present at the rotor windings. This action directly depends on the voltage and current relationships resulting from application of the turns ratio of the stator and rotor windings.

The motor "series" airgap thus balances the excess voltage flux wave not required by the rotor to maintain the rotating speed. In the transformer analogy, this would be equivalent to a high leakage reactance design with a mechanical separation between primary and secondary windings. In this specific case, the leakage reactance balances the excess flux when the secondary winding is shortcircuited.

So far, the discussion has established the theory of rotation for the armature. For the armature to actually rotate, the airgap flux wave must also rotate, either continuously, as in a three-phase AC system, or instantaneously, as in a single-phase AC system. For single-phase systems, a capacitor or separate start-winding is required to shift the phase of the airgap flux wave to start rotation. However, for electric vehicle use, we will consider only the three-phase power system since the three-phase AC system has a naturally occurring flux field rotation.

The transformer analogy of induction motors can also be extended to the relative size of the motor. The well known transformer equation relating flux density, applied voltage, core area, and frequency (a specific application of Faraday's law) applies directly to AC induction motors. Thus, for low frequency AC systems, the area and volume of stator and rotor iron required to support the applied voltage will be greater than for higher frequencies. Coupled with the naturally rotating flux wave of three-phase systems, this sets the physical dimensions of the motor. It also allows for a convenient control of motor speed by varying the applied frequency, since changing the frequency results in a change in the rotating flux field in the airgap. Generally, industrial induction motors can be operated over a minimum of 2/1 speed range with some operation of up to 4/1.

Electric vehicle application experience using AC induction motors has been favorable. Extensive design and testing of induction motor powered vehicles took place in the early 1970's. The test results were generally satisfactory--the major problem being the reliability of the variable frequency inverter. The development effort did, however, establish desirable characteristics for the induction motor (mainly reduced size and weight, and improved efficiency) for electric vehicle use.

H.3 Synchronous Motors. In the discussion dealing with induction motors, it was established that the rotor reactive force is developed by induced voltage and the resultant current is transformed from the stator winding. As the reactive force creates armature rotation, the actual armature positional relationship with respect to the induced rotor flux will be slightly retarded. As the motor approaches full speed, the positional relationship becomes relatively constant, and thus rotates at a speed equal to 3 to 10 percent of the applied frequency base speed. This difference in rotor speed as a ratio of base speed is defined as the slip speed.

A special case can be made for AC induction motor designs in which the slip ratio is held at unity. Under this circumstance the rotor speed and the field flux rotational speed are equal. Motors of this type thus have a synchronous speed relationship, and bear this name. Synchronous motors are characterized by having wound rotors which can be separately excited from an external voltage source, rather than excited through induction from the stator winding. This capability allows for establishing a high reactive force in the armature, even at zero rotor speed. It holds that the stator induced field flux and the rotor reactive force developed from separate power can be individually controlled. Since the rotor reactive force determines the motor torque and the stator frequency controls the motor speed, the synchronous motor has the inherent characteristics desirable for electric vehicle applications. An additional control characteristic is available in synchronous motors because of slip frequency. Since by definition, synchronous operation requires that the slip frequency be unity, a change in slip frequency requires a corresponding in rotor speed to maintain the motor magnetic circuit in balance. In synchronous motors, the slip ratio can be controlled by a change in the rotor

excitation. Thus for electric vehicle applications, either the stator frequency or rotor excitation may be changed to command acceleration or deceleration, as required.

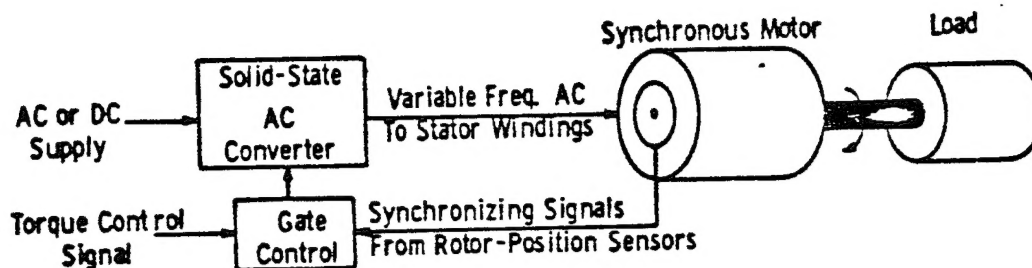
Recent developments in synchronous motors and generators have eliminated the requirement for direct excitation connections to the rotor windings. Figure H.3-1 illustrates the system for controlling the rotor excitation by additional components attached to the common output shaft. The key feature of this system is the integral AC exciter/alternator and rotating rectifiers. This system can produce the required rotor excitation very efficiently due to the transformation action of the alternator. System controllability is excellent due to the high gain available in the control loop. Due to the transformation characteristics of the AC exciter, small, low-power error signals can command the motor/generator system over the full-rated power range. Response times are very short and thus the system is very reactive to operator inputs. This command/control characteristic is desirable in electric vehicle drive systems to maintain both responsiveness and stability.

H.4 Permanent Magnet Brushless DC Motors. During the mid-1950's, development of high energy magnet materials allowed designers to employ these permanent magnets in motor structures as the source of rotor excitation. As permanent magnet materials have improved, designers have applied them to larger motors which at present range up to 50-100 Horsepower. Early development of the permanent magnet motor was characterized by simply substituting the magnet for a wound-field structure in shunt-wound DC motors. The motor thus performed in a similar fashion to the conventional, DC mechanically-commutated motor, except that motor speed increased linearly with applied voltage. This characteristic is due to the fixed, constant-level of field flux generated by the permanent magnets.

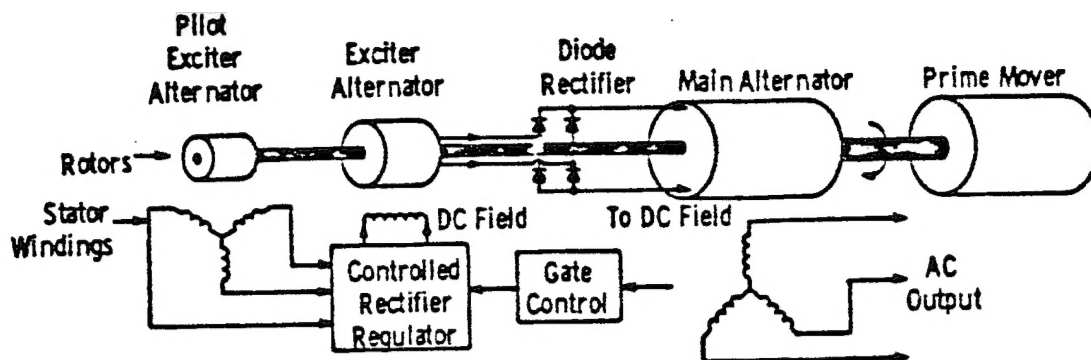
While the speed versus applied voltage linearity was recognized as a desirable characteristic, the speed versus torque curve reacts in an opposite manner. Thus, while speed increases with voltage, torque decreases with speed in a reasonably linear fashion. These features of the permanent magnet motor, while usable in many applications--including small electric vehicle drives, would not be successful in large electric vehicle drives where extreme performance is the requirement.

Within the past ten years, development efforts in permanent magnet motors have produced a true hybrid motor. These hybrid motors have many of the desirable characteristics of DC motors (such as speed versus voltage linearity) while being controlled and commutated from an AC source. This family is generally labeled "Brushless" DC motors.

Brushless DC motors are characterized by their construction which is similar to a conventional multiphase AC motor, except the usual peripheral field permanent magnets are replaced by a multiphase (usually three) winding powered by an electronic inverter. The inverter is operated at selected frequencies which are dependent on motor design and provide the electronic commutation function. The permanent magnets are attached to the rotor in a manner which



(a) High Frequency AC Synchronous Motor Drive



(b) High Frequency AC Synchronous Alternator

Figure H.3-1. Diagrammatic Representation of Brushless Excitation System

provides for field flux in the stator/rotor airgap. This design allows for considerable flexibility in the rotor design and the number of poles available for reacting with the rotor. These design variables result in two basic brushless motor designs: one having small rotor diameters, few poles, and a magnet length dependent upon the horsepower requirement; and one having large rotor diameters many poles and, relatively short magnet length. Generally these two motor types are classified as High Speed/Low Torque (HSLT), and Low Speed/High Torque (LSHT) designs.

Excellent thermal characteristics is one of the major features of the brushless motor design. With the heat-generating windings situated on the stator, low thermal resistance in the stator iron allows for relatively unimpeded heat flow to the outside motor shell. Appropriate cooling can be employed to removed this heat and maintain the motor at rated temperature. Very little heat is generated by the permanent magnet rotor structure and, consequently, the rotor temperature rise is minimized.

General reliability of brushless motors is very favorable. Care must be used in selecting the motor type, however, so that vibration and shock do not cause damage to the magnet structures. Although minor cracking of the magnets will not cause a major motor failure, cracks can cause degradation in motor performance. A more significant failure can result if the magnets fragment and produce chips which can lodge in the airgap.

Brushless DC motors offer desirable features to electric vehicle drives. The control characteristics, when considered with the capabilities of electronic commutation controllers, offer the potential for independent speed and torque control. Motor efficiency is high and the construction provides excellent thermal dissipation. Further, as defined by the vehicle specifications, the brushless motor may be designed for high- or low-speed operation with the appropriate resultant torques.

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